



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
18.01.2017 Bulletin 2017/03

(51) Int Cl.:
B21H 1/12 (2006.01)

(21) Application number: **15761174.0**

(86) International application number:
PCT/JP2015/001271

(22) Date of filing: **09.03.2015**

(87) International publication number:
WO 2015/136911 (17.09.2015 Gazette 2015/37)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

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(30) Priority: **12.03.2014 JP 2014049208**

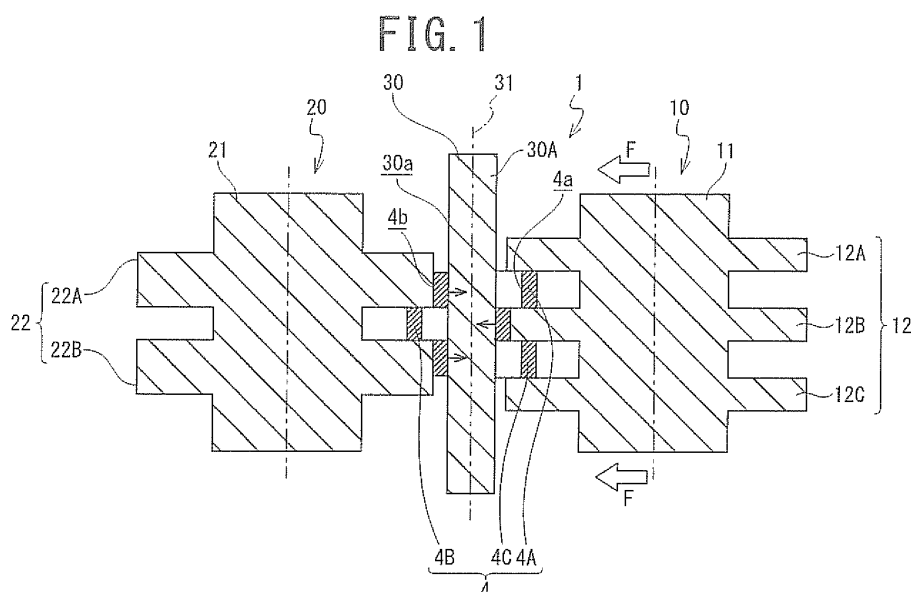
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(54) **ROLLING DEVICE AND ROLLING METHOD**

(57) A rolling processing device and a rolling processing method are provided to be capable of producing annular members by rolling-forming three or more cylindrical members at the same time while reducing the possibility of breakage of a mandrel. For this purpose, a rolling processing device (1) includes a forming roll (10),

a support roll (20), and a mandrel (30). Plural workpieces (4) are arranged on the mandrel (30) alternately in the radial direction of the mandrel (30). The rolling processing method includes an arranging process for arranging the workpieces (4) on the mandrel (30) and a rolling process.



Description

Summary

Technical Field

Technical Problem

[0001] The present invention relates to rolling processing devices and rolling processing methods, and relates to a rolling processing device for producing annular members applied to inner rings and outer rings of, for example, a rolling bearing, and a rolling processing method using the same.

Background Art

[0002] The annular members conventionally applied to the inner rings and outer rings of the rolling bearings and the like are produced by rolling (press) processing of annular workpieces. Examples of such rolling processing include the method disclosed in PTL 1. As illustrated in FIG. 16, a rolling processing device 100 including a support roll 101, a forming roll 102, and a mandrel 103 is used in the conventional rolling processing. A workpiece 104 is arranged such that the inner surface of the workpiece 104 abuts with the outer peripheral surface of the mandrel 103, and the outer peripheral surface of the workpiece 104 abuts with the inner peripheral surface of the forming roll 102. After that, the workpiece 104 is pressed by rotating the forming roll 102 and the mandrel 103 while making a rotary shaft of the forming roll 102 get closer to a rotary shaft of the mandrel 103, and is formed into an annular member.

[0003] In addition, PTL 2 discloses the technology for offsetting the bending moment and preventing breakage of the mandrel 103 in such a rolling processing device. PTL 2 addresses the offset of the bending moment with a mechanical structure.

[0004] The technologies disclosed in PTL 1 and PTL 2 are, however, those for forming a single annular member from a single workpiece in a single rolling process. Thus, the working efficiency has room for improvement.

[0005] In order to increase the productivity of forming annular members, PTL 3 discloses a technology for cold rolling two workpieces applied to a taper bearing all at one time.

Citation List

Patent Literature

[0006]

PTL 1: JP 62-176627 A

PTL 2: JP 56-111533 A

PTL 3: JP 2006-320927 A

[0007] In the technology disclosed in PTL 3, plural workpieces are produced by rolling at the same time, however, its intended use is limited to the taper bearing. Besides, the technology disclosed in PTL 3 is not suitable for rolling three or more workpieces at the same time.

[0008] When three or more workpieces are subject to the rolling process at the same time, as illustrated in FIG. 17, the load in the process also corresponds to three workpieces (approximately three times), and increases the distance between support points D. This results in an increase in the possibility of breaking the mandrel 103. This is because the forming force corresponding to three workpieces (approximately three times) is applied to the mandrel 103 in the same direction, and thus increases bending applied to the mandrel 103.

[0009] The present invention has been made in view of the above-described circumstances, and an object of the present invention is to provide a rolling processing device and a rolling processing method capable of producing annular members by rolling three or more workpieces at the same time and reducing the possibility of breakage of a mandrel.

Solution to Problem

[0010] In order to address the above problems, according to one aspect of the present invention, there is provided a rolling processing device including: a forming roll configured to abut with an outer peripheral surface of a cylindrical member; a support roll configured to abut with the outer peripheral surface of the cylindrical member; and a mandrel having an outer peripheral surface configured to abut with an inner peripheral surface of the cylindrical member. Rotary shafts of the forming roll, the support roll, and the mandrel are arranged to be capable of getting closer to one another, at least three of the cylindrical members are arranged on the outer peripheral surface of the mandrel alternately in a radial direction of the mandrel, a plurality of protrusions, each having a disc shape, are provided on the forming roll and the support roll depending on the number of the cylindrical members, and outer peripheral surfaces of the plurality of protrusions of at least one of the forming roll or the support roll are pressed against the outer peripheral surface of the cylindrical member.

[0011] In the above-described rolling processing device, at least a first engaging groove is provided on the outer peripheral surface of the mandrel, the first engaging groove having a diameter decreasing in an axial direction of the mandrel, and being configured to abut the inner peripheral surfaces of the three or more of the cylindrical members alternately in the radial direction of the mandrel.

[0012] In addition, in the above-described rolling processing device, a second engaging groove may be

provided on the outer peripheral surface of at least one of the forming roll or the support roll to be engaged with the outer peripheral surface of the cylindrical member and an end surface in the axial direction of the cylindrical member to correspond to the first engaging groove.

[0013] In addition, in the above-described rolling processing device, a plurality of the first engaging grooves may be provided depending on the number of the cylindrical members.

[0014] In addition, in the above-described rolling processing device, a pair of rotating bodies may be provided on at least one of the forming roll or the support roll to be arranged rotatably with respect to the forming roll and the support roll, which are opposed to each other in the axial direction, and are configured to bias both end surfaces of the cylindrical member in the axial direction.

[0015] Further, according to another aspect of the present invention, there is provided a rolling processing method comprising an arranging process for arranging a cylindrical member in a rolling processing device comprising a forming roll configured to abut with an outer peripheral surface of the cylindrical member, a support roll configured to abut with the outer peripheral surface of the cylindrical member, and a mandrel having an outer peripheral surface configured to abut with an inner peripheral surface of the cylindrical member, rotary shafts of the forming roll, the support roll, and the mandrel being arranged to be capable of getting closer to one another; and a rolling-forming process for rolling-forming the cylindrical member to expand a diameter of the cylindrical member by use of the forming roll and the mandrel to produce annular members. The arranging process is a process for arranging at least three of the cylindrical members in an axial direction of the mandrel with respect to a first engaging groove provided on the outer peripheral surface of the mandrel such that the inner peripheral surfaces of the at least three of the cylindrical members abut alternately in a radial direction of the mandrel and an outer peripheral surface of at least one of the protrusions of the forming roll or the support roll abuts with the outer peripheral surface of the cylindrical member.

[0016] Herein, in the above-described rolling processing method, a plurality of the first engaging grooves may be provided depending on the number of the cylindrical members.

[0017] In addition, in the above-described rolling processing method, a pair of rotating bodies may be provided on at least one of the forming roll or the support roll to be arranged rotatably with respect to the forming roll and the support roll, which are opposed to each other in the axial direction, and are configured to bias both end surfaces of the cylindrical member in the axial direction.

Advantageous Effects

[0018] In one embodiment of the present invention, a rolling processing device and a rolling processing method capable of producing annular members by rolling-form-

ing three or more workpieces at the same time while reducing the possibility of breakage of a mandrel can be provided.

5 Brief Description of Drawings

[0019]

FIG. 1 is a cross-sectional view of a state where workpieces are arranged (arranging process) in a rolling processing device and a rolling processing method, in a first embodiment of the present invention;

FIG. 2 is a cross-sectional view of a state where rolling-forming process of one side of the workpieces is completed (rolling process) in the rolling processing device and the rolling processing method, in the first embodiment of the present invention;

FIG. 3 is a cross-sectional view of a state where the rolling-forming process of the workpieces is completed in the rolling processing device and the rolling processing method, in the first embodiment of the present invention;

FIG. 4 is a cross-sectional view of a state where the rolling-forming process of workpieces is completed in the rolling processing device and the rolling processing method in one variation of the first embodiment of the present invention;

FIG. 5A and FIG. 5B are cross-sectional views of a state where the rolling-forming process of workpieces is completed in the case where the number of the workpieces is 2 (FIG. 5A) and the number of the workpieces is 4 (FIG. 5B) the rolling processing device and the rolling processing method, in another variation of the first embodiment of the present invention;

FIG. 6 is a cross-sectional view of a state where workpieces are arranged (arranging process) in the rolling processing device and the rolling processing method, in a second embodiment of the present invention;

FIG. 7 is a cross-sectional view of a state where the rolling-forming process of one side of the workpieces is completed (rolling process) in the rolling processing device and the rolling processing method, in the second embodiment of the present invention;

FIG. 8 is a cross-sectional view of a state where the rolling-forming process of the workpieces is completed in the rolling processing device and the rolling processing method, in the second embodiment of the present invention;

FIG. 9 is a cross-sectional view of a state where rolling-forming process of workpieces is completed in the rolling processing device and the rolling processing method, in one variation of the second embodiment of the present invention;

FIG. 10A and FIG. 10B are cross-sectional views of a state where rolling-forming process of workpieces

is completed in the case where the number of the workpieces is 2 (FIG. 10A) and the number of the workpieces is 4 (FIG. 10B) in the rolling processing device and the rolling processing method, in another variation of the second embodiment of the present invention;

FIG. 11A is a cross-sectional view of a state where workpieces are arranged (arranging process) in the rolling processing device and the rolling processing method, in a third embodiment of the present invention;

FIG. 11B is an enlarged view of a main part;

FIG. 12A and FIG. 12B are cross-sectional views of a state where workpieces are arranged (arranging process) in the case where the number of the workpieces is 2 (FIG. 12A) and the number of the workpieces is 4 (FIG. 12B) in the rolling processing device and the rolling processing method, in one variation of the third embodiment of the present invention;

FIG. 13 is a cross-sectional view of a state where rolling-forming process of workpieces is completed in the rolling processing device and the rolling processing method, in a fourth embodiment of the present invention;

FIG. 14 is an enlarged view of a main part of FIG. 13; FIG. 15A is a cross-sectional view of a state when rolling-forming process of two workpieces is completed in the rolling processing device and the rolling processing method, in one variation of the fourth embodiment of the present invention;

FIG. 15B is a cross-sectional view of a state where rolling-forming process of four workpieces is completed, in the rolling processing device and the rolling processing method, in another variation of the fourth embodiment of the present invention;

FIG. 16 is a cross-sectional view of a state when a workpiece is rolling-processed in a conventional rolling processing device; and

FIG. 17 is a cross-sectional view of a state when three or more workpieces are rolling-processed in the conventional rolling processing device.

Description of Embodiments

[0020] In the following detailed description, a number of specific details will be described for providing complete understanding of embodiments of the present invention. However, it is apparent that one or more embodiments should be practicable without such specific details. In addition, well-known structures and devices are illustrated by schematic diagrams for simplifying the drawings.

[0021] Hereinafter, a rolling processing device and a rolling processing method in some embodiments of the present invention will be described with reference to the drawings.

First embodiment

[0022] FIG. 1 is a cross-sectional view of a state where workpieces are set in the rolling processing device and the rolling processing method, in a first embodiment of the present invention.

Rolling processing device

[0023] As illustrated in FIG. 1, a rolling processing device 1 in the present embodiment includes a forming roll 10, a support roll 20, and a mandrel 30. The forming roll 10, the support roll 20, and the mandrel 30 respectively include rotary shafts 11, 21, and 31, which are respectively arranged parallel to one another, and are respectively arranged rotatably around the rotary shafts 11, 21, and 31.

Forming roll

[0024] In the forming roll 10, plural disc-shaped protrusions 12 (12A, 12B, and 12C) are provided on the rotary shaft 11 at a predetermined interval in the axial direction. Such a predetermined interval is same in dimension as the thickness of cylindrical members (workpieces) 4 in the axial direction at the completion of processing. The cylindrical members 4 are the targets to be rolling-formed. In other words, the rolling processing device in the present embodiment is configured to set the above-described intervals of the protrusions 12A, 12B, and 12C, and has a function of limiting the workpieces 4 not to extend in the axial direction in a rolling-forming process. It is to be noted that the protrusion 12B of the protrusions 12A, 12B, and 12C abuts with an outer peripheral surface 4b of the workpiece 4. Thus, the protrusion 12B presses the outer peripheral surface of the mandrel 30 through the workpiece 4. The forming roll 10 is arranged rotatably together with the mandrel 30 with the protrusion 12B abutting with the mandrel 30 through the workpiece 4. Although the protrusions 12 can be integrally formed with the rotary shaft 11, the protrusions 12 as separate bodies may be fixed on the rotary shaft 11 in a method such as screwing, welding, or bonding. In the case of integral forming, the forming roll 10 having high strength and rigidity can be produced, but the manufacturing cost may be increased, because the forming roll 10 is manufactured by cutting or forging a cylindrical material having a large diameter. In contrast, in a configuration in which the protrusions 12 as separate bodies are joined to the rotary shaft 11 by welding, the strength and rigidity are slightly lower than those of the protrusions 12 that are integrally formed, but the material cost and the processing cost can be reduced. In addition, in the case of screwing, even when a part of the forming roll 10 is damaged when used, its use can be continued by replacing only the damaged part. Furthermore, the protrusions 12 of various sizes can be attached to the rotary shaft 11. Thus, the forming roll 10 can be applied to various kinds and

the manufacturing cost of annular members can be reduced.

Mandrel

[0025] The mandrel 30 has a cylindrical-shaped main body 30A having an outer diameter smaller than the inner diameter of the workpiece 4. It is to be noted that, in FIG. 1, the rotary shaft 31 of the mandrel 30 also serves as the main body 30A.

[0026] As will be described below, inner peripheral surfaces 4a of three or more workpieces 4 abut with the main body 30A alternately in the radial direction of the mandrel 30, and the mandrel 30 is rotatable together with the forming roll 10 through the workpieces 4.

Support roll

[0027] Plural disc-shaped protrusions 22 (22A and 22B) are provided on the support roll 20 at a predetermined interval in the axial direction. The predetermined interval can be almost the same in dimension as the thickness of the cylindrical members (workpieces) 4 in the axial direction at the completion of processing. Each of the protrusions 22A and 22B abuts with the outer peripheral surface 4b of the workpiece 4, and is arranged rotatably together with the rotary shaft 21. Although the protrusions 22 can be integrally formed with the rotary shaft 21, the protrusions 22 as separate bodies may be fixed on the rotary shaft 21 in a method such as screwing, welding, or bonding. Advantages obtained when the protrusions 22 are integrally formed or separately formed are similar to those in the case of the forming roll 10. The protrusions 12 of the forming roll 10 and the protrusions 22 of the support roll 20 may be integrally formed or separately formed, as necessary.

[0028] Here, plural protrusions 12 and the plural protrusions 22 are provided depending on the number of the workpieces 4. For example, when n is the number of the workpieces 4, m is the number of the protrusions 12, and k is the number of the protrusions 22, the protrusions 12 and the protrusions 22 are provided so as to satisfy $n + 2 = m + k$.

[0029] The protrusions 22A and 22B of the support roll 20 configured in this manner abut with the outer peripheral surface of the mandrel 30 through the workpieces 4, and are arranged rotatably together with the mandrel 30.

Rolling processing method

[0030] Next, the rolling processing method using the above-described rolling processing device 1 in one embodiment will be described below with reference to the drawings.

[0031] In the rolling processing device 1, the position of one of the forming roll 10 or the support roll 20 is fixed, whereas the other includes an inherent drive source to

be capable of performing translational motion actively. The mandrel 30 is arranged to be capable of translating and rotating passively in accordance with a deformation of the workpieces 4. It is to be noted that each of the forming roll 10 and the support roll 20 includes a drive source for active rotation, which is not illustrated.

[0032] The present embodiment will be described under the presumption that the position of the rotary shaft 21 of the support roll 20 is fixed, the rotary shaft 11 of the forming roll 10 is arranged to be capable of performing translational motion by the above-described drive source, the mandrel 30 rotates passively in accordance with the deformation of the workpieces 4, and the rotary shaft 31 of the mandrel 30 is arranged to be capable of translating passively in accordance with the deformation of the workpieces 4. Such a configuration eliminates the need of positional control, except for the forming roll 10. The configuration of the rolling processing device 1 is simplified. It is to be noted that, in one variation, the mandrel 30 may be fixed, and the forming roll 10 and the support roll 20 may perform the translational motion toward the mandrel 30.

[0033] In such a variation, the forming roll 10 and the support roll 20 may be driven independently, or one of the rolls may be rotated and the other of the rolls and the mandrel may be rotated dependently.

[0034] The rolling processing method in the present embodiment includes at least an arranging process and a rolling process, and may include another process as necessary. In the present embodiment, there are some specific technical aspects in the arranging process.

Arranging process

[0035] As illustrated in FIG. 1, in the above-described arranging process, plural (for example, three) workpieces 4 are arranged such that respective end surfaces of the protrusions 12 of the forming roll 10 and the protrusions 22 of the support roll 20 abut with the outer peripheral surfaces 4b of the plural workpieces 4. The workpieces 4 are inserted into the mandrel 30.

[0036] In the arranging process in the present embodiment, plural (for example, three) workpieces 4 are arranged such that the inner peripheral surfaces 4a of the plural workpieces 4 are arranged alternately in the radial direction of the mandrel 30 with respect to the main body 30A of the mandrel 30, and the outer peripheral surfaces 4b of the workpieces 4 abut with the outer peripheral surfaces of the protrusions 12 and the protrusions 22.

[0037] As illustrated in FIG. 1, in this situation, a workpiece 4A and a workpiece 4B are arranged such that the outer peripheral surface of the protrusion 22A abuts with the outer peripheral surface 4b of the workpiece 4A, and one end surface of the protrusion 22A in the axial direction abuts with one end surface of the workpiece 4B in the axial direction. In addition, as illustrated in FIG. 1, the workpiece 4B and a workpiece 4C are arranged such that the outer peripheral surface of the protrusion 22B

abuts with the outer peripheral surface 4b of the workpiece 4C, and one end surface of the protrusion 22A in the axial direction abuts with the other end surface of the workpiece 4B in the axial direction. In other words, the workpiece 4B is arranged to be sandwiched between the protrusion 22A and the protrusion 22B in the axial direction to limit the movement in the axial direction.

[0038] On the other hand, the forming roll 10 is arranged such that one end surface of the protrusion 12A of the forming roll 10 abuts with one end surface (for example, upper end surface) of the workpiece 4A in the axial direction to limit the movement of the workpiece 4A in one (upward) direction. In addition, the protrusion 12B is arranged such that the outer peripheral surface thereof abuts with the outer peripheral surface 4a of the workpiece 4B, one end surface thereof abuts with the other end surface (for example, lower end surface) of the workpiece 4A in the axial direction, and the other end surface thereof abuts with one end surface (for example, upper end surface) of the workpiece 4C in the axial direction. This configuration limits the movement of the workpiece 4A in the other (downward) direction and the movement of the workpiece 4C in one (upward) direction. Similarly, the protrusion 12C abuts with the other end surface (for example, lower end surface) of the workpiece 4C in the axial direction, and is arranged to limit the movement of the workpiece 4C in the other (downward) direction.

Rolling process

[0039] The above-described rolling process is a rolling-forming process that extends the diameters of the workpieces 4A, 4B, and 4C, by the movement of the forming roll 10, to produce the annular members 2. Inner surfaces 4a of the workpieces 4A, 4B, and 4C alternately abut with an outer peripheral surface 30a of the main body 30A of the mandrel 30.

[0040] Specifically, the forming roll 10 is moved in a direction in which a distance between the rotary shaft 31 of the mandrel 30 and the rotary shaft 11 of the forming roll 10 reduces, by a drive source that is not illustrated, while rotating the protrusions 12A, 12B, and 12C of the forming roll 10 by the above-described drive source. Accordingly, the workpiece 4B is sandwiched between the protrusion 12B of the forming roll 10 and the outer surface 30a of the mandrel 30, and the workpiece 4B is rolled.

[0041] When the rolling of the workpiece 4B is completed, the protrusions 12A and 12C of the forming roll 10 abut with the outer peripheral surface 30a of the mandrel 30. After that, as illustrated in FIG. 2, the forming roll 10 is further made to perform the translational motion, and the protrusions 12A and 12C of the forming roll 10 press the mandrel 30, so that the mandrel 30 performs rotation and translational motion passively, and the workpieces 4A and 4C sandwiched between the outer peripheral surface 30a of the mandrel 30 and the protrusions 22A and 22B of the support roll 20 are rolled.

[0042] In the present embodiment, the rolling force F

exerted from the forming roll 10 is transmitted through a path of the forming roll 10, the workpiece 4B, the mandrel 30, the workpieces 4A and 4C, and the support roll 20, in this order. In other words, the rolling force F is exerted to the workpiece 4B, and the rolling force F/2 is applied to each of the workpieces 4A and 4C. Thus, the workpiece 4B deforms faster than the workpieces 4A and 4C. After that, the rolling by the protrusions 12A, 12B, and 12C is progressed, and the rolling-forming process of the workpieces 4A, 4B and 4C is completed when the thicknesses of the workpieces 4A, 4B and 4C in the radial direction reach predetermined thicknesses (see FIG. 3).

[0043] As described above, the workpieces 4 are arranged alternately in the radial direction with respect to the mandrel 30 in the present embodiment, so that the force alternately acts on the mandrel 30 as illustrated in FIG. 3. Bending that occurs in the mandrel 30 can be reduced while forming the workpieces 4. This means that, in a configuration of a general rolling processing device, forming of workpieces plays the role of a support roll (a roll that presses a mandrel).

[0044] In addition, the inter-fulcrum distance D between the protrusions 22A and 22B of the support roll 20 is almost the same as the inter-fulcrum distance in the case where only a single workpiece 4 is rolling-processed. In other words, almost the same force as that in the case where one workpiece 4 is rolling-formed is exerted to the mandrel 30 by the arrangement of the plural workpieces 4 in the present embodiment. Thus, more workpieces 4 can be rolling-formed at the same time while preventing breakage of the mandrel 30.

[0045] Here, as another variation of the present embodiment, as illustrated in FIG. 4, the number of the workpieces 4 that are rolling-formed at the same time can be increased. For example, five workpieces 4 can be rolling-formed at the same time as illustrated in FIG. 4. Even if still more workpieces 4 are formed at the same time, as illustrated in FIG. 4, the workpieces 4 arranged alternately that are rolled suppress the bending that may occur in the mandrel 30. Accordingly, more workpieces 4 can be rolling-formed at the same time without worrying about the breakage of the mandrel 30.

[0046] In addition, in the conventional rolling processing device, when the protrusions are made to support the mandrel, considerable space is necessary in the width direction. However, the mandrel is supported by the forming force of the workpieces as in the present embodiment. Therefore, a rolling processing device capable of rolling-forming plural workpieces at the same time with a compact size is provided.

[0047] In addition, in another variation of the present embodiment, as illustrated in FIG. 5A and FIG. 5B, the number of the workpieces 4 that are rolling-formed at the same time can be not odd numbers but even numbers. For example, as illustrated in FIG. 5A, two workpieces 4A and 4B can be rolling-formed at the same time. Specifically, the workpiece 4A and the workpiece 4B are arranged such that the outer peripheral surface of the pro-

trusion 22A abuts with the outer peripheral surface 4b of the workpiece 4A, and one end surface of the protrusion 22A in the axial direction abuts with one end surface of the workpiece 4B in the axial direction. In addition, the workpiece 4B is arranged such that one end surface of the protrusion 22A in the axial direction abuts with the other end surface of the workpiece 4B in the axial direction. In other words, the workpiece 4B is arranged to be sandwiched between the protrusion 22A and the protrusion 22B in the axial direction to limit the movement in the axial direction.

[0048] On the other hand, the forming roll 10 is arranged such that one end surface of the protrusion 12A of the forming roll 10 abuts with one end surface (for example, upper end surface) of the workpiece 4A in the axial direction to limit the movement of the workpiece 4A in one (upward) direction. In addition, the protrusion 12B is arranged such that the outer peripheral surface thereof abuts with the outer peripheral surface 4a of the workpiece 4B, and one end surface thereof abuts with the other end surface (for example, lower end surface) of the workpiece 4A in the axial direction. Accordingly, the movement of the workpiece 4A in the other (downward) direction is limited.

[0049] In addition, as illustrated in FIG. 5B, four workpieces 4A to 4D can be rolling-formed at the same time. Specifically, three disc-shaped protrusions 22 (22A, 22B, and 22C) are provided on the support roll 20 at predetermined intervals in the axial direction.

[0050] The workpiece 4A and the workpiece 4B are arranged such that the outer peripheral surface of the protrusion 22A abuts with the outer peripheral surface 4b of the workpiece 4A, and one end surface of the protrusion 22B in the axial direction abuts with one end surface of the workpiece 4B in the axial direction. In addition, the workpiece 4B and the workpiece 4C are arranged such that the outer peripheral surface of the protrusion 22B abuts with the outer peripheral surface 4b of the workpiece 4C, and one end surface of the protrusion 22B in the axial direction abuts with the other end surface of the workpiece 4B in the axial direction. In addition, the workpiece 4C and the workpiece 4D are arranged such that the outer peripheral surface of the protrusion 22B abuts with the outer peripheral surface 4b of the workpiece 4C, and one end surface of the protrusion 22C in the axial direction abuts with one end surface of the workpiece 4D in the axial direction.

[0051] In other words, the workpiece 4B is arranged to be sandwiched between the protrusion 22A and the protrusion 22B in the axial direction to limit the movement in the axial direction. In addition, the workpiece 4D is arranged to be sandwiched between the protrusion 22B and the protrusion 22C in the axial direction to limit the movement in the axial direction.

[0052] On the other hand, the forming roll 10 is arranged such that one end surface of the protrusion 12A of the forming roll 10 in the axial direction abuts with one end surface (for example, upper end surface) of the work-

piece 4A in the axial direction to limit the movement of the workpiece 4A in one (upward) direction. In addition, the protrusion 12B is arranged such that the outer peripheral surface thereof abuts with the outer peripheral surface 4a of the workpiece 4B, one end surface thereof in the axial direction abuts with the other end surface (for example, lower end surface) of the workpiece 4A in the axial direction, and the other end surface thereof abuts with one end surface (for example, upper end surface) of the workpiece 4C in the axial direction. In addition, the protrusion 12C is arranged such that the outer peripheral surface thereof abuts with the outer peripheral surface 4a of the workpiece 4D, and one end surface thereof in the axial direction abuts with one end surface (for example, upper end surface) of the workpiece 4C in the axial direction.

[0053] This configuration limits the movement of the workpiece 4A in the other (downward) direction and the movement of the workpiece 4C in one (upward) direction. Similarly, the protrusion 12C abuts with the other end surface (for example, lower end surface) of the workpiece 4C in the axial direction, and is arranged to limit the movement of the workpiece 4C in the other (downward) direction.

[0054] It is to be noted that, when the number of the workpieces 4 that are rolling-formed at the same time but an even number in this manner, instead of an odd number, by setting the rigidity and the support rigidity of the mandrel 30 so as to resist the moment for inclining the mandrel 30, the bending that may occur in the mandrel 30 can be suppressed. Accordingly, more workpieces 4 can be rolling-formed at the same time without worrying about the breakage of the mandrel 30.

[0055] As described above, according to the rolling processing device and the rolling processing method in the present embodiment, annular members can be produced by rolling-forming three or more cylindrical members at the same time while reducing the possibility of breakage of the mandrel. Accordingly, plural cylindrical members can be formed in a processing period of time almost the same as the conventional one, and the productivity can be drastically increased. In addition, in the present embodiment, plural workpieces can be rolling-formed at the same time without worrying about the breakage of a mandrel.

Second embodiment

[0056] FIG. 6 is a cross-sectional view of a state where workpieces are set in the rolling processing device and the rolling processing method, in a second embodiment of the present invention.

Rolling processing device

[0057] As illustrated in FIG. 6, a rolling processing device 1 of the present embodiment has a forming roll 10, a support roll 20, and a mandrel 30. The forming roll 10,

the support roll 20, and the mandrel 30 have rotary shafts 11, 21, 31 respectively arranged parallel to one another, and are respectively arranged rotatably around the rotary shafts 11, 21, 31.

Forming roll

[0058] In the forming roll 10, plural disc-shaped protrusions 12 (12A, 12B, and 12C) are provided on the rotary shaft 11 at predetermined intervals in the axial direction. It is preferable that the predetermined intervals have almost the same dimensions as the thickness dimensions of cylindrical members (workpieces) 4, which are targets to be rolling-formed, in the axial direction at the completion of processing. In other words, the rolling processing device of the present embodiment, which sets the intervals of the protrusions 12A, 12B, and 12C as described above, has a limiting function by which the workpieces 4 are not spread in the axial direction in a rolling-forming process. It is to be noted that the protrusion 12B among the protrusions 12A, 12B, and 12C abuts with an outer peripheral surface 4b of the workpiece 4. Thus, the protrusion 12B presses the outer peripheral surface of the mandrel 30 through the workpiece 4. The forming roll 10 is arranged rotatably together with the mandrel 30 with the protrusion 12B thereof being in contact with the mandrel 30 through the workpiece 4.

Mandrel

[0059] The mandrel 30 includes a cylindrical-shaped main body 30A having an outer diameter smaller than the inner diameter of the workpiece 4, and a first engaging groove 32. The diameter of the first engaging groove 32 decreases in the axial direction of the rotary shaft 31 of the mandrel 30. It is to be noted that, in FIG. 6, the rotary shaft 31 of the mandrel 30 also serves as the main body 30A.

[0060] As described below, inner peripheral surfaces 4a of three or more of the workpieces 4 abut with the first engaging groove 32 alternately in the radial direction of the mandrel 30, and the mandrel 30 is rotatable together with the forming roll 12A, 12B, and 12C through the workpieces 4.

Support roll

[0061] A plural disc-shaped protrusions 22 (22A and 22B) are provided on the support roll 20 at a predetermined interval in the axial direction. It is preferable that the predetermined interval have almost the same dimension as the thickness dimensions of the cylindrical members (workpieces) 4, which are targets to be rolling-formed, in the axial direction at the completion of processing. Each of the protrusions 22A and 22B abuts with the outer peripheral surface 4b of the workpiece 4, and is arranged rotatably together with the rotary shaft 21.

[0062] In addition, on the outer peripheral surfaces of

the protrusions 22A and 22B, and second engaging grooves 23A and 23B that correspond to the first engaging groove 32 and are engaged with the outer peripheral surfaces 4b and end surfaces in the axial direction of the workpieces 4 are provided, respectively.

[0063] Here, the plural protrusions 12 and the plural protrusions 22 are provided depending on the number of the workpieces 4. For example, when the number of the workpieces 4 is n , the number of the protrusions 12 is m , and the number of the protrusions 22 is k , the protrusions 12 and the protrusions 22 are provided so as to satisfy $n + 2 = m + k$.

[0064] The protrusions 22A and 22B of the support roll 20 configured in this manner abut with the outer peripheral surface of the mandrel 30 through the workpieces 4 and are arranged rotatably together with the mandrel 30.

Rolling processing method

[0065] Next, an embodiment of the rolling processing method using the above-described rolling processing device 1 will be described below with reference to the drawings.

[0066] In the rolling processing device 1, the position of one of the forming roll 10 and the support roll 20 is fixed, and the other has an inherent drive source and can perform translational motion actively. The mandrel 30 is arranged to be capable of performing rotation and translational motion passively in accordance with the deformation of the workpieces 4.

[0067] In one embodiment, described description will be given under the presumption that the position of the rotary shaft 21 of the support roll 20 is fixed, the rotary shaft 11 of the forming roll 10 is arranged to be capable of performing translational motion by the above-described drive source, and the mandrel 30 is arranged to be capable of performing rotation and translational motion passively in accordance with the deformation of the workpieces 4. In such a configuration, only the position of the forming roll 10 has to be controlled. Thus, the configuration of the rolling processing device 1 is simplified. It is to be noted that, in one variation, the position of the mandrel 30 is fixed, and the forming roll 10 and the support roll 20 translationally move toward the mandrel 30 may be adopted. In such a variation, the forming roll 10 and the support roll 20 may be driven independently, or a variation in which one of the rolls is rotated, and the other roll and the mandrel are rotated dependently may be used.

[0068] The rolling processing method of the present embodiment includes at least an arranging process and a rolling process, and may include another process as necessary. The present embodiment has a specific technical feature in the arranging process.

Arranging process

[0069] As illustrated in FIG. 6, the above-described ar-

ranging process is a process for arranging plural (for example, three) workpieces 4 such that respective end surfaces of the protrusions 12 of the forming roll 10 and the protrusions 22 of the support roll 20 abut with the outer peripheral surfaces 4b of the plural workpieces 4 into which the mandrel 30 is inserted.

[0070] Here, the arranging process of the present embodiment is a process for arranging the plural (for example, three) workpieces 4 such that the inner peripheral surfaces 4a of the plural workpieces 4 are alternated in the radial direction of the mandrel 30 with respect to the first engaging groove 32 of the mandrel 30, and the outer peripheral surfaces 4b of the workpieces 4 abut with the outer peripheral surfaces of the protrusions 12 and the protrusions 22.

[0071] As illustrated in FIG. 6, at this time, in the variation in which the second engaging groove 23A is provided on the outer peripheral surface of the protrusion 22A, a workpiece 4A is arranged such that the outer peripheral surface of the second engaging groove 23A is engaged with the outer peripheral surface 4b of the workpiece 4A, and an end surface of the second engaging groove 23A in the axial direction is engaged with one end surface of the workpiece 4A in the axial direction. In addition, as illustrated in FIG. 6, in the variation in which the second engaging groove 23B is provided on the outer peripheral surface of the protrusion 22B, a workpiece 4C is arranged such that the outer peripheral surface of the second engaging groove 23A is engaged with the outer peripheral surface 4b of the workpiece 4C, and an end surface of the second engaging groove 23A in the axial direction is engaged with one end surface of the workpiece 4C in the axial direction.

[0072] In addition, the workpiece 4B is arranged to be sandwiched between the protrusion 22A and the protrusion 22B in the axial direction to limit the movement in the axial direction.

[0073] On the other hand, the forming roll 10 is arranged such that one end surface of the protrusion 12A of the forming roll 10 abuts with one end surface (for example, upper end surface) of the workpiece 4A in the axial direction to limit the movement of the workpiece 4A in one (upward) direction. In addition, the protrusion 12B is arranged such that the outer peripheral surface thereof abuts with the outer peripheral surface 4a of the workpiece 4B, one end surface thereof abuts with the other end surface (for example, lower end surface) of the workpiece 4A in the axial direction, and the other end surface thereof abuts with one end surface (for example, upper end surface) of the workpiece 4C in the axial direction. Accordingly, the movement of the workpiece 4A in the other (downward) direction and the movement of the workpiece 4C in one (upward) direction are limited. Similarly, the protrusion 12C is arranged such that one end surface thereof abuts with the other end surface (for example, lower end surface) of the workpiece 4C in the axial direction to limit the movement of the workpiece 4C in the other (downward) direction.

Rolling process

[0074] The above-described rolling process is a rolling-forming process that expands the diameters of the workpieces 4A, 4B, and 4C having inner peripheral surfaces 4a abutting with an outer peripheral surface 30a of the first engaging part 32 of the mandrel 30 alternately, by the movement of the forming roll 10, to produce annular members 2.

[0075] Specifically, the forming roll 10 is moved in a direction in which a distance between the rotary shaft 31 of the mandrel 30 and the rotary shaft 11 of the forming roll 10 is reduced, by a drive source that is not illustrated, while rotating the protrusions 12A, 12B, and 12C of the forming roll 10 by the above-described drive source. Accordingly, the workpiece 4B is sandwiched between the protrusion 12B of the forming roll 10 and the outer peripheral surface 30a of the mandrel 30, and the workpiece 4B is rolled.

[0076] When the rolling of the workpiece 4B is completed, the protrusions 12A and 12C of the forming roll 10 abut with the outer peripheral surface 30a of the mandrel 30. After that, as illustrated in FIG. 7, the forming roll 10 is further made to perform translational motion, and the protrusions 12A and 12C of the forming roll 10 press the mandrel 30, so that the mandrel 30 performs rotation and translational motion passively, and the workpieces 4A and 4C sandwiched between the outer peripheral surface 30a of the mandrel 30 and the protrusions 22A and 22B of the support roll 20 are rolled.

[0077] In the present embodiment, the protrusion 12B of the forming roll 10 rolls the workpiece 4B with the outer peripheral surface thereof directly pressing the outer peripheral surface of the workpiece 4B. At this time, the rolling force F from the forming roll 10 is transmitted through a path of the forming roll 10 → the workpiece 4B → the mandrel 30 → the workpieces 4A and 4C → the support roll 20. In other words, the rolling force F is applied to the workpiece 4B, and the rolling force F/2 is applied to each of the workpieces 4A and 4C. Thus, the workpiece 4B deforms faster than the workpieces 4A and 4C. After that, the rolling by the protrusions 12A, 12B, and 12C is progressed, and the rolling-forming process of the workpieces 4A, 4B, and 4C is completed when the thicknesses of the workpieces 4A, 4B, and 4C in the radial direction become predetermined thicknesses (see FIG. 8).

[0078] As described above, the workpieces 4 are arranged alternately in the radial direction with respect to the mandrel 30 in the present embodiment, so that the force alternately acts on the mandrel 30 as illustrated in FIG. 8, and bending that occurs in the mandrel 30 can be reduced while forming the workpieces 4. This means that, in a configuration of a general rolling processing device, forming of workpieces plays the role of a support roll (a roll that presses a mandrel).

[0079] In addition, an inter-fulcrum distance D between the protrusions 22A and 22B of the support roll 20 is

almost the same as an inter-fulcrum distance in the case where only one workpiece 4 is rolling-processed. In other words, almost the same force as that in the case where one workpiece 4 is rolling-formed is applied to the mandrel 30 by the arrangement of the plural workpieces 4 in the present embodiment. Thus, more workpieces 4 can be rolling-formed at the same time while preventing breakage of the mandrel 30.

[0080] Here, in one variation of the present embodiment, as illustrated in FIG. 9, the number of the workpieces 4 that are rolling-formed at the same time can be increased. For example, five workpieces 4 can be rolling-formed at the same time as illustrated in FIG. 9.

[0081] At this time, second engaging grooves 13A and 13C that correspond to the first engaging groove 32 and are engaged with the outer peripheral surfaces 4b and end surfaces in the axial direction of the workpieces 4A and 4E are respectively provided at the protrusions 12A and 12C of the forming roll 10. Here, on which protrusions 12 (22) the second engaging grooves 13 (23) are provided is selected depending on the number of the workpieces 4 to be processed.

[0082] As described above, even if still more workpieces 4 are formed at the same time, as illustrated in FIG. 9, the workpieces 4 arranged alternately are rolled. Thus, bending applied to the mandrel 30 can be suppressed. Accordingly, more workpieces 4 can be rolling-formed at the same time without worrying about breakage of the mandrel 30.

[0083] In addition, in the conventional rolling processing device, when the protrusions are made to support the mandrel, considerable space becomes necessary in the width direction. However, when the mandrel is supported by the forming force of the workpieces as in the present embodiment, a rolling processing device that rolling-forms plural workpieces at the same time but is extremely compact can be provided.

[0084] In addition, in another variation of the present embodiment, as illustrated in FIG. 10A and FIG. 10B, the number of the workpieces 4 that are rolling-formed at the same time can be not odd numbers but even numbers. For example, as illustrated in FIG. 10A, two workpieces 4A and 4B can be rolling-formed at the same time. Specifically, in another variation, the second engaging groove 23A is provided on the outer peripheral surface of the protrusion 22A, the workpiece 4A is arranged such that the outer peripheral surface of the second engaging groove 23A is engaged with the outer peripheral surface 4b of the workpiece 4A, and an end surface of the second engaging groove 23A in the axial direction is engaged with one end surface of the workpiece 4A in the axial direction.

[0085] In addition, the workpiece 4B is arranged to be sandwiched between the protrusion 22A and the protrusion 22B in the axial direction to limit the movement in the axial direction.

[0086] On the other hand, the forming roll 10 is arranged such that one end surface of the protrusion 12A

of the forming roll 10 abuts with one end surface (for example, upper end surface) of the workpiece 4A in the axial direction to limit the movement of the workpiece 4A in one (upward) direction. In addition, the protrusion 12B is arranged such that the outer peripheral surface thereof abuts with the outer peripheral surface 4a of the workpiece 4B, and one end surface thereof abuts with the other end surface (for example, lower end surface) of the workpiece 4A in the axial direction. Accordingly, the movement of the workpiece 4A in the other (downward) direction is limited. In addition, on the protrusion 12B, a second engaging groove 13B that corresponds to the first engaging groove 32 and is engaged with the outer peripheral surface 4b and the other end surface in the axial direction of the workpiece 4B is provided. Accordingly, the movement of the workpiece 4B in the other (downward) direction is limited.

[0087] In addition, as illustrated in FIG. 10B, four workpieces 4A to 4D can be rolling-formed at the same time. Specifically, three disc-shaped protrusions 22 (22A, 22B, and 22C) are provided on the support roll 20 at predetermined intervals in the axial direction.

[0088] On the protrusion 22A, the second engaging groove 23A that corresponds to the first engaging groove 32 and is engaged with the outer peripheral surface 4b and one end surface (for example, upper end surface) in the axial direction of the workpiece 4A is provided.

[0089] In addition, three disc-shaped protrusions 12 (12A, 12B, and 12C) are provided on the forming roll 10 at predetermined intervals in the axial direction. On the outer peripheral surface of the protrusion 12C, the second engaging groove 13C that corresponds to the first engaging groove 32 and is engaged with the outer peripheral surface 4b and the other end surface (for example, lower end surface) in the axial direction of the workpiece 4D is provided.

[0090] In such a variation, the workpiece 4A is arranged such that the outer peripheral surface of the second engaging groove 23A is engaged with the outer peripheral surface 4b of the workpiece 4A, and an end surface of the second engaging groove 23A in the axial direction is engaged with one end surface of the workpiece 4A in the axial direction. Here, the workpiece 4A is arranged to be sandwiched between the protrusion 12A and the protrusion 12B in the axial direction to limit the movement in the axial direction. In addition, the workpiece 4B is arranged to be sandwiched between the protrusion 22A and the protrusion 22B in the axial direction to limit the movement in the axial direction. In addition, the workpiece 4C is arranged to be sandwiched between the protrusion 22A and the protrusion 22B in the axial direction to limit the movement in the axial direction. In addition, the workpiece 4D is arranged such that the outer peripheral surface of the second engaging groove 13C is engaged with the outer peripheral surface 4b of the workpiece 4D, and an end surface of the second engaging groove 13C in the axial direction is engaged with the other end surface of the workpiece 4D in the axial direc-

tion. Here, the workpiece 4D is arranged to be sandwiched between the protrusion 22B and the protrusion 22C in the axial direction to limit the movement in the axial direction.

[0091] Here, when even numbers of the workpieces 4 are rolling-formed at the same time, in addition to the above-described variations with reference to FIG. 10A and FIG. 10B, by using a rolling processing device in which the maximum number of workpieces that can be stored is odd numbers, processing may be performed with the number of workpieces decreased by one. For example, with reference to FIG. 9, by using the above-described "rolling processing device in which the number of workpieces is five", four workpieces the number of which is smaller than the five by one can be rolling-formed at the same time.

[0092] As described above, according to the rolling processing device and the rolling processing method of the present embodiment, annular members can be produced by rolling-forming three or more cylindrical members at the same time while reducing the possibility of breakage of a mandrel. Accordingly, plural cylindrical members can be formed in processing time almost the same as the conventional processing time, and the productivity can be drastically increased. In addition, according to the present embodiment, plural workpieces can be rolling-formed at the same time without worrying about breakage of a mandrel.

[0093] In particular, in the present embodiment, the workpieces 4 can be prevented from increasing the widths while the workpieces 4 are being deformed by the first engaging groove 32 provided on the mandrel 30 and the second engaging grooves 13 (23) provided on at least one of the forming roll 10 and the support roll 20.

[0094] In addition, the first engaging groove 32 and the second engaging grooves 13 (23) are provided to improve the workability when the workpiece 4 are set in the mandrel 30 in the above-described arranging process, and to improve the positioning accuracy of the workpieces 4 in the axial direction.

Third embodiment

[0095] Next, a third embodiment of the rolling processing device and the rolling processing method will be described with reference to the drawings. It is to be noted that the present embodiment is merely different from the second embodiment in the variation of the first engaging groove provided on the mandrel and the second engaging grooves provided on the forming roll and the support roll. Thus, the description of the same components denoted by the same reference numerals as in the above-described embodiments will be sometimes omitted. FIG. 11A and FIG. 11B are cross-sectional views of a processing outline of annular members the rolling processing device and the rolling processing method, in the third embodiment of the present invention.

[0096] As illustrated in FIG. 11A and FIG. 11B, in the

present embodiment, plural first engaging grooves 32 are provided depending on the number of the workpieces 4. Specifically, the first engaging groove 32 with which all of the inner peripheral surfaces 4a of the workpieces 4A, 4B, and 4C abut does not have one groove shape that is flush in the axial direction, but plural reduced-diameter first engaging grooves 32A, 32B, and 32C are provided on the main body 30A independently.

[0097] In addition, on the protrusion 12B of the forming roll 10, the second engaging groove 13B that corresponds to the first engaging groove 32B and is engaged with the outer peripheral surface 4b and both end surfaces in the axial direction of the workpiece 4B is provided.

[0098] In addition, on the protrusions 22A and 22B of the support roll 20, the second engaging grooves 23A and 23B that correspond to the first engaging grooves 32A and 32C and are engaged with the outer peripheral surfaces 4b and both end surfaces in the axial direction of the workpieces 4A and 4C are provided.

[0099] The workpieces 4 may extend in the axial direction in addition to expanding of the diameters, depending on rolling conditions, and the present embodiment is provided for solving such a situation.

[0100] In other words, the second engaging grooves 12B, 23A, and 23B are provided as in the present embodiment, so that extending of the workpieces 4 in the axial direction can be suppressed. Therefore, it is possible to provide a rolling processing device that rolling-forms plural workpieces at the same time with higher accuracy, while keeping an inter-fulcrum distance D small, and a rolling processing method using the above-described rolling processing device.

[0101] In addition, as another variation of the present embodiment, as illustrated in FIG. 12A and FIG. 12B, the number of the workpieces 4 that are rolling-formed at the same time can be not odd numbers but even numbers. For example, as illustrated in FIG. 12A, two workpieces 4A and 4B can be rolling-formed at the same time. Specifically, the plural first engaging grooves 32 are provided depending on the number of the workpieces 4. Specifically, the first engaging groove 32 with which all of the inner peripheral surfaces 4a of the workpieces 4A and 4B abut does not have one groove shape that is flush in the axial direction, but plural reduced-diameter first engaging grooves 32A, 32B are provided on the main body 30A independently.

[0102] In addition, on the protrusion 12B of the forming roll 10, the second engaging groove 13B that corresponds to the first engaging groove 32B and is engaged with the outer peripheral surface 4b and both end surfaces in the axial direction of the workpiece 4B is provided.

[0103] In addition, on the protrusion 22A of the support roll 20, the second engaging groove 23A that corresponds to the first engaging groove 32A and is engaged with the outer peripheral surface 4b and both end surfaces in the axial direction of the workpiece 4A is provided.

ed. It is to be noted that, on the protrusion 22B of the support roll 20, the second engaging groove 23B as illustrated in FIG. 11 is not provided.

[0104] In addition, as illustrated in FIG. 12B, four workpiece 4A to 4D can be rolling-formed at the same time. Specifically, three disc-shaped protrusions 22 (22A, 22B, and 22C) are provided on the support roll 20 at predetermined intervals in the axial direction.

[0105] The protrusion 22A includes the second engaging groove 23A that corresponds to the first engaging groove 32A and is engaged with the outer peripheral surface 4b and both end surfaces in the axial direction of the workpiece 4A. In addition, the protrusion 22B includes the second engaging groove 23B that corresponds to the first engaging groove 32C and that is engaged with the outer peripheral surface 4b and both end surfaces in the axial direction of the workpiece 4C.

[0106] In addition, three disc-shaped protrusions 12 (12A, 12B, and 12C) are provided on the forming roll 10 at predetermined intervals in the axial direction. On the outer peripheral surface of the protrusion 12B, the second engaging groove 13B that corresponds to the first engaging groove 32B and is engaged with the outer peripheral surface 4b and both end surfaces in the axial direction of the workpiece 4B is provided. In addition, on the outer peripheral surface of the protrusion 12C, the second engaging groove 13C that corresponds to the first engaging groove 32D and is engaged with the outer peripheral surface 4b and both end surfaces in the axial direction of the workpiece 4D is provided.

[0107] In such a variation, the workpiece 4A is arranged such that the outer peripheral surface of the second engaging groove 23A is engaged with the outer peripheral surface 4b of the workpiece 4A, and end surfaces of the second engaging groove 23A in the axial direction are engaged with both end surfaces of the workpiece 4A in the axial direction. Here, the workpiece 4A is arranged to be sandwiched between the protrusion 12A and the protrusion 12B in the axial direction to limit the movement in the axial direction.

[0108] In addition, the workpiece 4B is arranged such that the outer peripheral surface of the second engaging groove 13B is engaged with the outer peripheral surface 4b of the workpiece 4B, and end surfaces of the second engaging groove 13B in the axial direction are engaged with both end surfaces of the workpiece 4B in the axial direction. Here, the workpiece 4B is arranged to be sandwiched between the protrusion 22A and the protrusion 22B in the axial direction to limit the movement in the axial direction.

[0109] In addition, the workpiece 4C is arranged such that the outer peripheral surface of the second engaging groove 23B is engaged with the outer peripheral surface 4b of the workpiece 4C, and end surfaces of the second engaging groove 23B in the axial direction are engaged with both end surfaces of the workpiece 4C in the axial direction. Here, the workpiece 4C is arranged to be sandwiched between the protrusion 12B and the protrusion

12C in the axial direction to limit the movement in the axial direction.

[0110] In addition, the workpiece 4D is arranged such that the outer peripheral surface of the second engaging groove 13C is engaged with the outer peripheral surface 4b of the workpiece 4D, and end surfaces of the second engaging groove 13C in the axial direction are engaged with both end surfaces of the workpiece 4D in the axial direction. Here, the workpiece 4D is arranged to be sandwiched between the protrusion 22B and the protrusion 22C in the axial direction to limit the movement in the axial direction.

[0111] Here, when even numbers of the workpieces 4 are rolling-formed at the same time, in addition to the above-described variations with reference to FIG. 12A and FIG. 12B, by using a rolling processing device in which the maximum number of workpieces that can be stored is odd numbers, processing may be performed with the number of workpieces decreased by one. For example, by using a "rolling processing device in which the number of workpieces is five", four workpieces the number of which is smaller than the five by one can be rolling-formed at the same time.

Fourth embodiment

[0112] Next, a fourth embodiment of the rolling processing device and the rolling processing method will be described with reference to the drawings. It is to be noted that the present embodiment is merely different from the second embodiment in that a rotating body is provided. Thus, the description of the same components denoted by the same reference numerals as in the above-described embodiments will be sometimes omitted. FIG. 13 and FIG. 14 are cross-sectional views of a processing outline of annular members in the rolling processing device and the rolling processing method, in the fourth embodiment of the present invention.

[0113] As illustrated in FIG. 13 and FIG. 14, in the present embodiment, pairs of rotating bodies 50 that bias both end surfaces of the workpieces 4 in the axial direction are provided on the forming roll 10 and the support roll 20. The rotating bodies 50 each have a rotary shaft, and are radially and rotatably arranged on end surfaces of the protrusions 12 and the protrusions 22 in the axial direction, which are opposed to one another in the axial direction. It is to be noted that the rotating bodies 50 may be arranged on at least one of the forming roll 10 and the support roll 20, and are preferably arranged on the forming roll 10 and the support roll 20.

[0114] The workpieces 4 may extend in the axial direction in addition to expanding of the diameters, depending on rolling conditions, and the present embodiment is a variation for solving it, as in the third embodiment. Hereinafter, the workpiece 4B will be specifically described as an example. As illustrated in FIG. 14, on the side where the inner peripheral surface 4a of the workpiece 4B abuts with the outer peripheral surface of the first engaging

groove 32 of the mandrel 30, the workpiece 4B is sandwiched by the outer peripheral surface of the protrusion 12B in the radial direction. In addition, on the opposite side in the radial direction from the side in contact with the outer peripheral surface of the first engaging groove 32, both end surfaces of the workpiece 4B in the axial direction are sandwiched between the pair of rotating bodies 50B, 50B provided on the inner surface sides of the protrusions 22A and 22B in the axial direction, which are opposed to each other.

[0115] In the case where the workpiece 4B arranged in this manner, on the side in contact with the outer peripheral surface 30a of the mandrel 30 extends in the axial direction by the rolling process, when the part is moved to the side sandwiched between the pair of rotating bodies 50B, 50B due to the rotation of the mandrel 40, the pair of rotating bodies 50B, 50B biases and pushes the workpiece 4B in the axial direction such that the workpiece 4B regains the original dimension in the axial direction.

[0116] In addition, as illustrated in FIG. 13, in the present embodiment, the friction force acting between the end surfaces of the workpieces 4 and the end surfaces of the protrusions 12 and the protrusions 22 can be reduced by providing the rotating bodies 50, so that the forming roll 10 and the support roll 20 are smoothly rotated, and the energy necessary for rolling processing can be reduced. Furthermore, damage such as seizure on the workpieces 4, the protrusions 12, and the protrusions 22 can be prevented.

[0117] In addition, although not illustrated, as another variation of the present embodiment, as illustrated in FIG. 15A and FIG. 15B, the number of the workpieces 4 that are rolling-formed at the same time can be not odd numbers but even numbers. For example, as illustrated in FIG. 15A, two workpieces 4A and 4B can be rolling-formed at the same time. Specifically, two disc-shaped protrusions 22 (22A and 22B) are provided on the support roll 20 at a predetermined interval in the axial direction.

[0118] On the protrusion 22A, the second engaging groove 23A that corresponds to the first engaging groove 32 and is engaged with the outer peripheral surface 4b and one end surface (for example, upper end surface) in the axial direction of the workpiece 4A is provided.

[0119] In addition, two disc-shaped protrusions 12 (12A, 12B) are provided on the forming roll 10 at a predetermined interval in the axial direction.

[0120] In such a variation, the workpiece 4A is arranged such that the outer peripheral surface of the second engaging groove 23A is engaged with the outer peripheral surface 4b of the workpiece 4A, and an end surface of the second engaging groove 23A in the axial direction is engaged with one end surface of the workpiece 4A in the axial direction. Here, the workpiece 4A is arranged to be sandwiched between the protrusion 12A and the protrusion 12B in the axial direction to limit the movement in the axial direction. In addition, on the opposite side in the radial direction from the side in contact

with the outer peripheral surface of the first engaging groove 32, both end surfaces of the workpiece 4A in the axial direction are sandwiched between the pair of rotating bodies 50A, 50A provided on the inner surface sides of the protrusions 12A, 12B in the axial direction, which are opposed to each other.

[0121] In addition, on the side where the inner peripheral surface 4a of the workpiece 4B abuts with the outer peripheral surface of the first engaging groove 32 of the mandrel 30, the workpiece 4B is sandwiched by the outer peripheral surface of the protrusion 12B in the radial direction. In addition, on the opposite side in the radial direction from the side in contact with the outer peripheral surface of the first engaging groove 32, both end surfaces of the workpiece 4B in the axial direction are sandwiched between the pair of rotating bodies 50B, 50B provided on the inner surface sides of the protrusions 22A and 22B in the axial direction, which are opposed to each other.

[0122] In addition, as illustrated in FIG. 15B, four workpieces 4A to 4D can be rolling-formed at the same time. Specifically, three disc-shaped protrusions 22 (22A, 22B, and 22C) are provided on the support roll 20 at predetermined intervals in the axial direction.

[0123] On the protrusion 22A, the second engaging groove 23A that corresponds to the first engaging groove 32 and is engaged with the outer peripheral surface 4b and one end surface in the axial direction of the workpiece 4A is provided.

[0124] In addition, three disc-shaped protrusions 12 (12A, 12B, and 12C) are provided on the forming roll 10 at predetermined intervals in the axial direction.

[0125] Here, pairs of rotating bodies 50 (50A to 50D) that bias both end surfaces of the workpieces 4 in the axial direction are provided on the forming roll 10 and the support roll 20. The rotating bodies 50 each have a rotary shaft, and are radially and rotatably arranged on end surfaces of the protrusions 12 and the protrusions 22 in the axial direction, which are opposed to one another in the axial direction. It is to be noted that the rotating bodies 50 may be arranged on at least one of the forming roll 10 and the support roll 20, and are preferably arranged on the forming roll 10 and the support roll 20.

[0126] In such a variation, the workpiece 4A is arranged such that the outer peripheral surface of the second engaging groove 23A is engaged with the outer peripheral surface 4b of the workpiece 4A, and an end surface of the second engaging groove 23A in the axial direction is engaged with one end surface of the workpiece 4A in the axial direction. Here, the workpiece 4A is arranged to be sandwiched between the protrusion 12A and the protrusion 12B in the axial direction to limit the movement in the axial direction. In addition, on the opposite side in the radial direction from the side in contact with the outer peripheral surface of the first engaging groove 32, both end surfaces of the workpiece 4A in the axial direction are sandwiched between the pair of rotating bodies 50A, 50A provided on the inner surface sides

of the protrusions 12A, 12B in the axial direction, which are opposed to each other.

[0127] In addition, on the side where the inner peripheral surface 4a of the workpiece 4B abuts with the outer peripheral surface of the first engaging groove 32 of the mandrel 30, the workpiece 4B is sandwiched by the outer peripheral surface of the protrusion 12B in the radial direction. In addition, on the opposite side in the radial direction from the side in contact with the outer peripheral surface of the first engaging groove 32, both end surfaces of the workpiece 4B in the axial direction are sandwiched between the pair of rotating bodies 50B, 50B provided on the inner surface sides of the protrusions 22A and 22B in the axial direction, which are opposed to each other.

[0128] In addition, on the side where the inner peripheral surface 4a of the workpiece 4C abuts with the outer peripheral surface of the first engaging groove 32 of the mandrel 30, the workpiece 4C is sandwiched by the outer peripheral surface of the protrusion 22B in the radial direction. In addition, on the opposite side in the radial direction from the side in contact with the outer peripheral surface of the first engaging groove 32, both end surfaces of the workpiece 4C in the axial direction are sandwiched between the pair of rotating bodies 50C, 50C provided on the inner surface sides of the protrusions 22A and 22B in the axial direction, which are opposed to each other.

[0129] In addition, on the side where the inner peripheral surface 4a of the workpiece 4D abuts with the outer peripheral surface of the first engaging groove 32 of the mandrel 30, the workpiece 4D is sandwiched by the outer peripheral surface of the protrusion 12C in the radial direction. In addition, on the opposite side in the radial direction from the side in contact with the outer peripheral surface of the first engaging groove 32, both end surfaces of the workpiece 4D in the axial direction are sandwiched between the pair of rotating bodies 50D, 50D provided on the inner surface sides of the protrusions 22B, 22C in the axial direction, which are opposed to each other.

[0130] Here, when even numbers of the workpieces 4 are rolling-formed at the same time, in addition to the above-described variations with reference to FIG. 15A and FIG. 15B, by using a rolling processing device in which the maximum number of workpieces that can be stored is odd numbers, processing may be performed with the number of workpieces decreased by one. For example, by using a "rolling processing device in which the number of workpieces is five", four workpieces the number of which is smaller than the five by one can be rolling-formed at the same time.

[0131] Heretofore, although the rolling processing device and the rolling processing method according to the present invention have been described, the rolling processing device and the rolling processing method according to the present invention are not limited to the above-described embodiments, and various modifications can be made without departing from the spirit of the

invention. For example, the first engaging groove is provided on the mandrel in the above-described embodiments, but if plural workpieces can be held without the first engaging groove, it is not necessary to provide the first engaging groove.

[0132] Heretofore, although the present invention has been described with reference to the specific embodiments, it is not intended to limit the invention by the description. By referring to the description of the present invention, various modifications of the disclosed embodiments and other embodiments of the present invention are apparent to those skilled in the art. Therefore, it should be understood that claims cover these modifications or embodiments included in the scope and spirit of the present invention.

Reference Signs List

[0133]

1	rolling processing device
2	annular member
4	cylindrical member (workpiece)
10	support roll
11	rotary shaft
12	protrusion
13	second engaging groove
20	forming roll
21	rotary shaft
22	protrusion
23	second engaging groove
30	mandrel
31	rotary shaft
32	first engaging groove
50	rotating body

Claims

1. A rolling processing device comprising:

a forming roll configured to abut with an outer peripheral surface of a cylindrical member;
a support roll configured to abut with the outer peripheral surface of the cylindrical member;
and
a mandrel having an outer peripheral surface configured to abut with an inner peripheral surface of the cylindrical member,

wherein rotary shafts of the forming roll, the support roll, and the mandrel are arranged to be capable of getting closer to one another,
wherein at least three of the cylindrical members are arranged on the outer peripheral surface of the mandrel alternately in a radial direction of the mandrel, wherein a plurality of protrusions, each having a disc shape, are provided on the forming roll and the sup-

- port roll depending on the number of the cylindrical members, and
wherein outer peripheral surfaces of the plurality of protrusions of at least one of the forming roll or the support roll are pressed against the outer peripheral surface of the cylindrical member. 5
2. The rolling processing device according to claim 1, wherein at least a first engaging groove is provided on the outer peripheral surface of the mandrel, the first engaging groove having a diameter decreasing in an axial direction of the mandrel, and being configured to abut the inner peripheral surfaces of the three or more of the cylindrical members alternately in the radial direction of the mandrel. 10
3. The rolling processing device according to claim 2, wherein a second engaging groove is provided on the outer peripheral surface of at least one of the forming roll or the support roll to be engaged with the outer peripheral surface of the cylindrical member and an end surface in the axial direction of the cylindrical member to correspond to the first engaging groove. 20
4. The rolling processing device according to any one of claims 1 to 3, wherein a plurality of the first engaging grooves are provided depending on the number of the cylindrical members. 25
5. The rolling processing device according to any one of claims 1 to 4, wherein a pair of rotating bodies are provided on at least one of the forming roll or the support roll to be arranged rotatably with respect to the forming roll and the support roll, which are opposed to each other in the axial direction, and are configured to bias both end surfaces of the cylindrical member in the axial direction. 30
6. A rolling processing method comprising: 40
- an arranging process for arranging a cylindrical member in a rolling processing device comprising a forming roll configured to abut with an outer peripheral surface of the cylindrical member, a support roll configured to abut with the outer peripheral surface of the cylindrical member, and a mandrel having an outer peripheral surface configured to abut with an inner peripheral surface of the cylindrical member, rotary shafts of the forming roll, the support roll, and the mandrel being arranged to be capable of getting closer to one another; and 50
- a rolling-forming process for rolling-forming the cylindrical member to expand a diameter of the cylindrical member by use of the forming roll and the mandrel to produce annular members, 55
- wherein the arranging process is a process for arranging at least three of the cylindrical members in an axial direction of the mandrel with respect to a first engaging groove provided on the outer peripheral surface of the mandrel such that the inner peripheral surfaces of the at least three of the cylindrical members abut alternately in a radial direction of the mandrel and an outer peripheral surface of at least one of the protrusions of the forming roll or the support roll abuts with the outer peripheral surface of the cylindrical member.
7. The rolling processing method according to claim 6, wherein a plurality of the first engaging grooves are provided depending on the number of the cylindrical members.
8. The rolling processing method according to claim 6 or 7, wherein a pair of rotating bodies are provided on at least one of the forming roll or the support roll to be arranged rotatably with respect to the forming roll and the support roll, which are opposed to each other in the axial direction, and are configured to bias both end surfaces of the cylindrical member in the axial direction.

FIG. 1

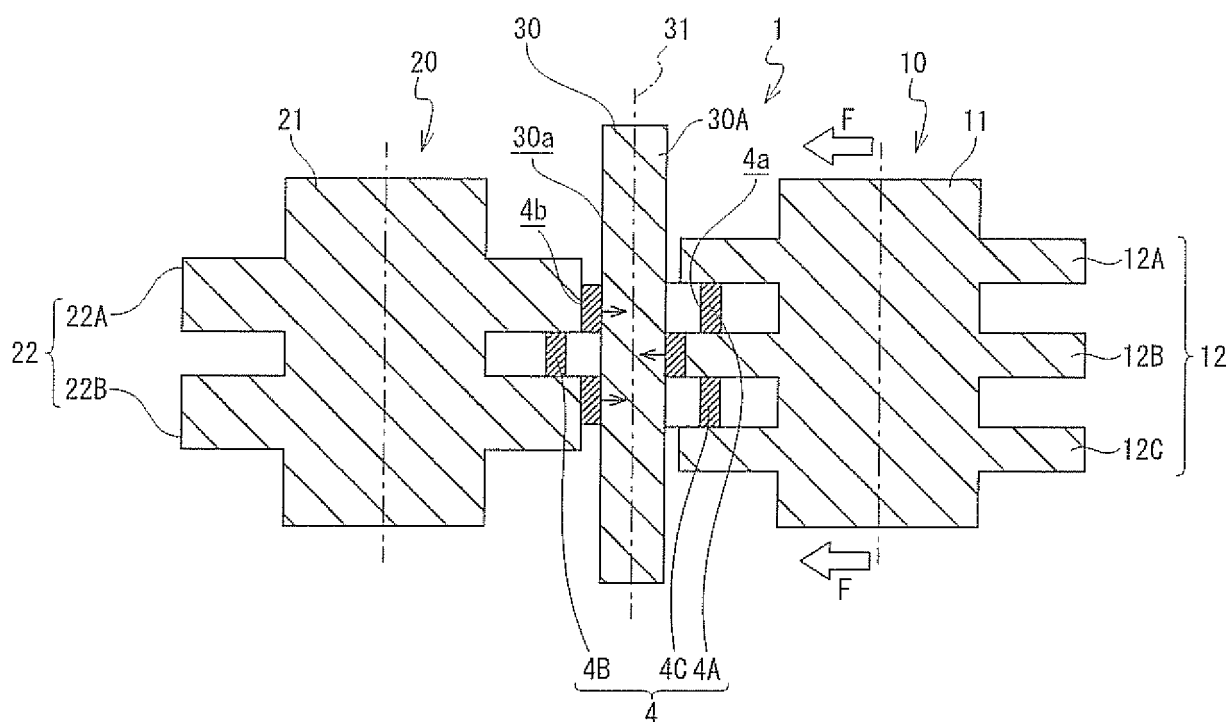


FIG. 2

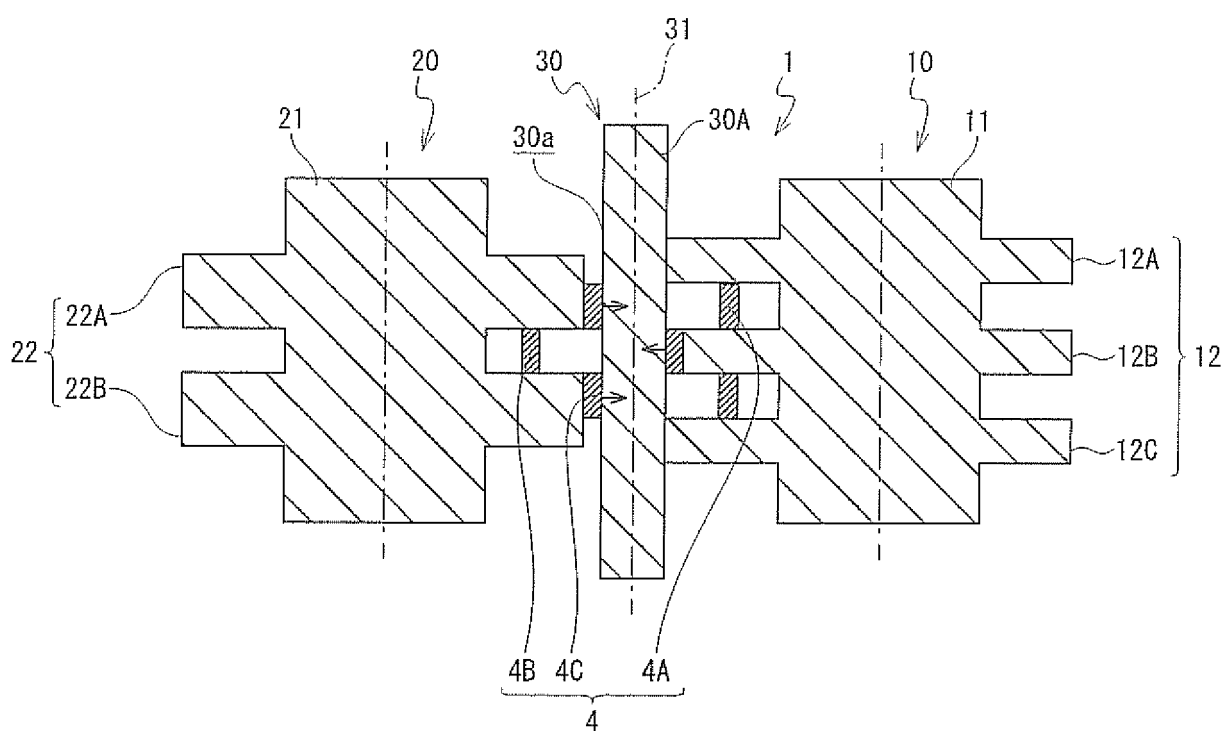


FIG. 3

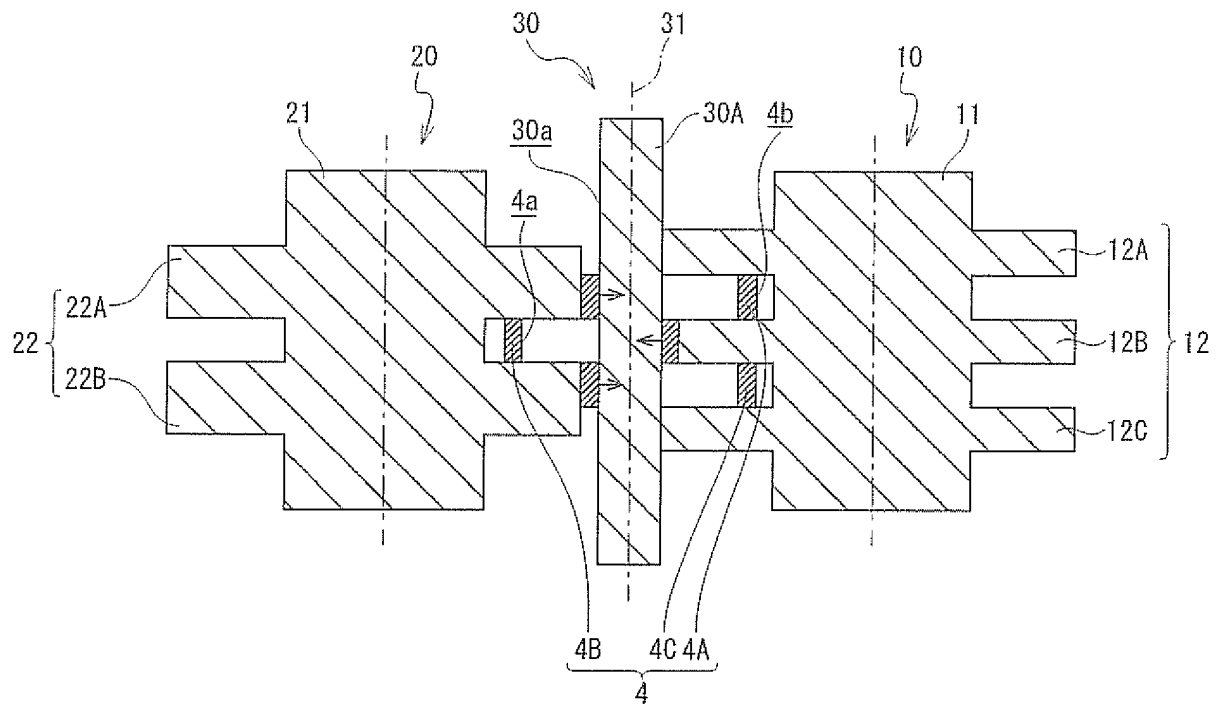


FIG. 4

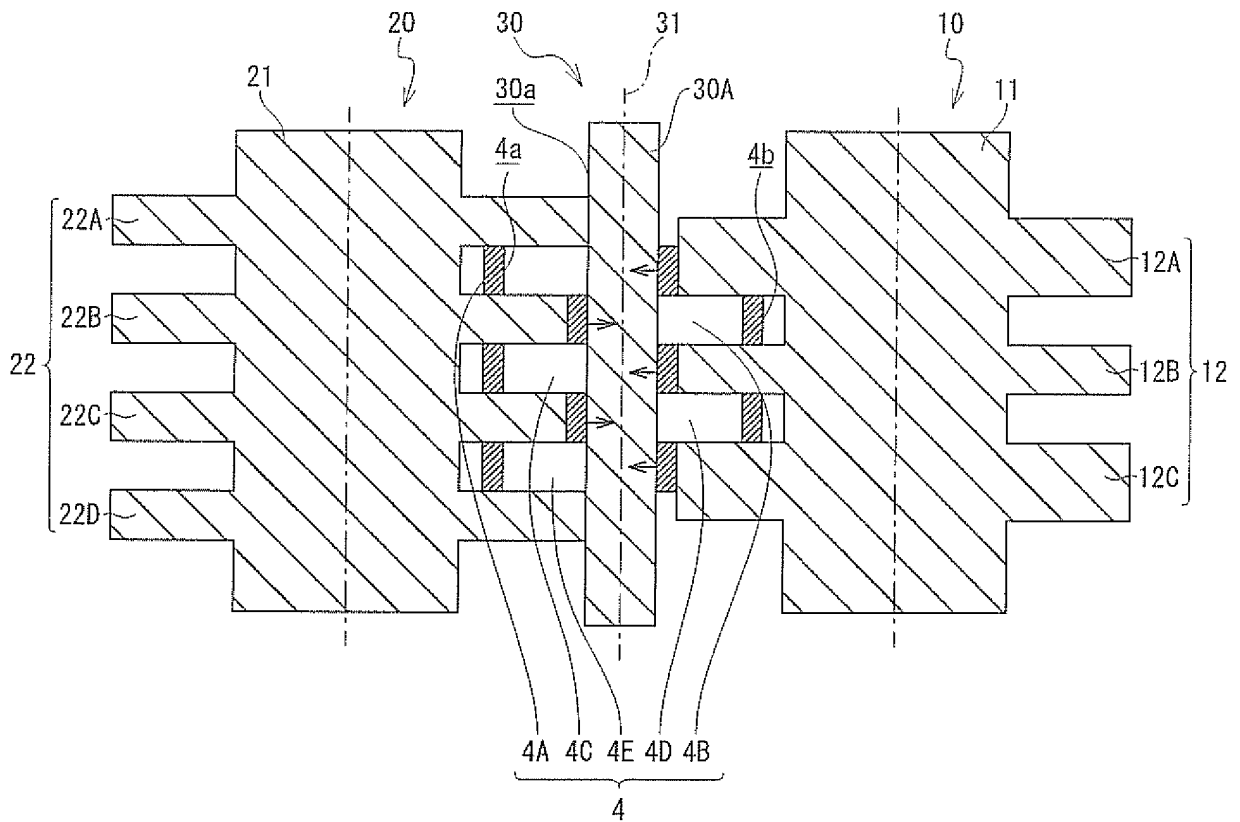


FIG. 5A

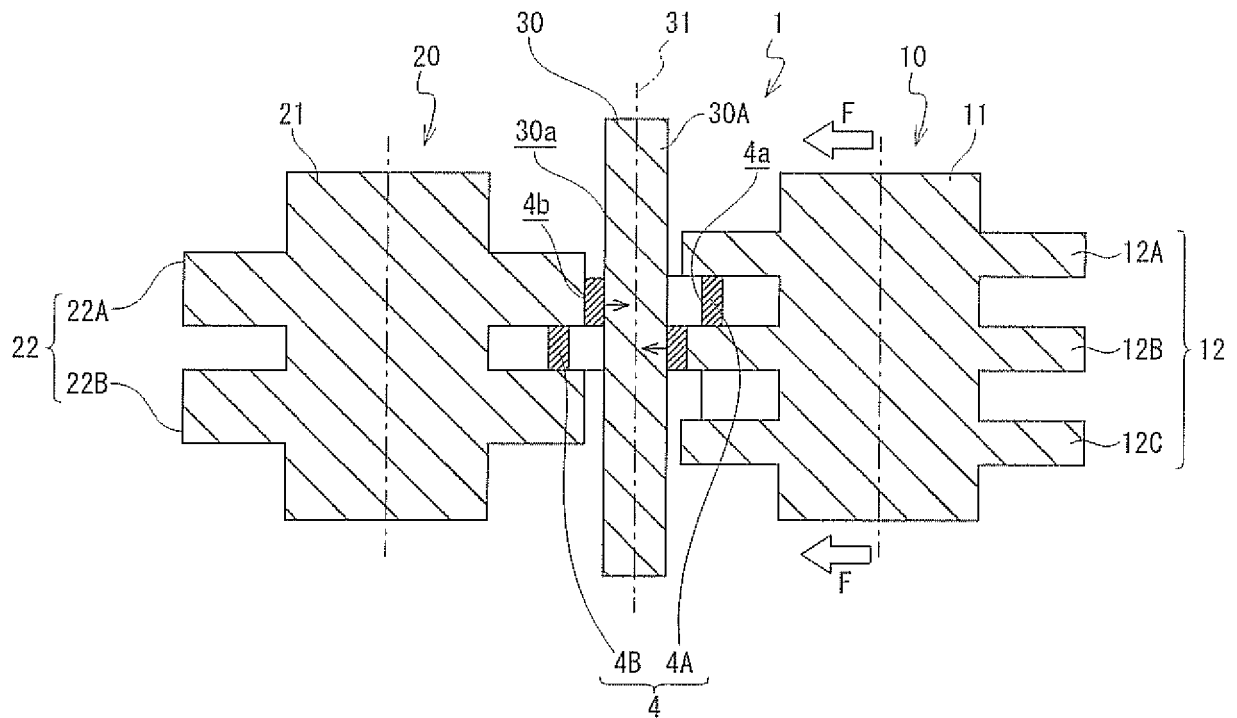


FIG. 5B

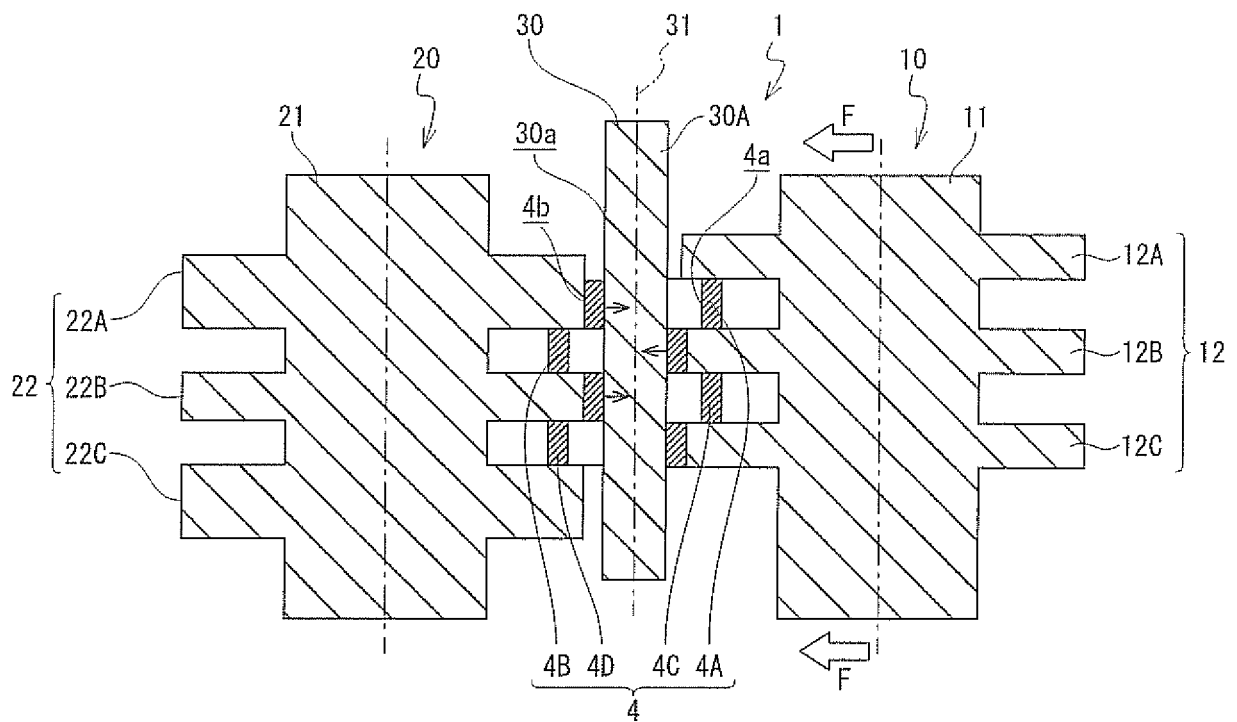


FIG. 6

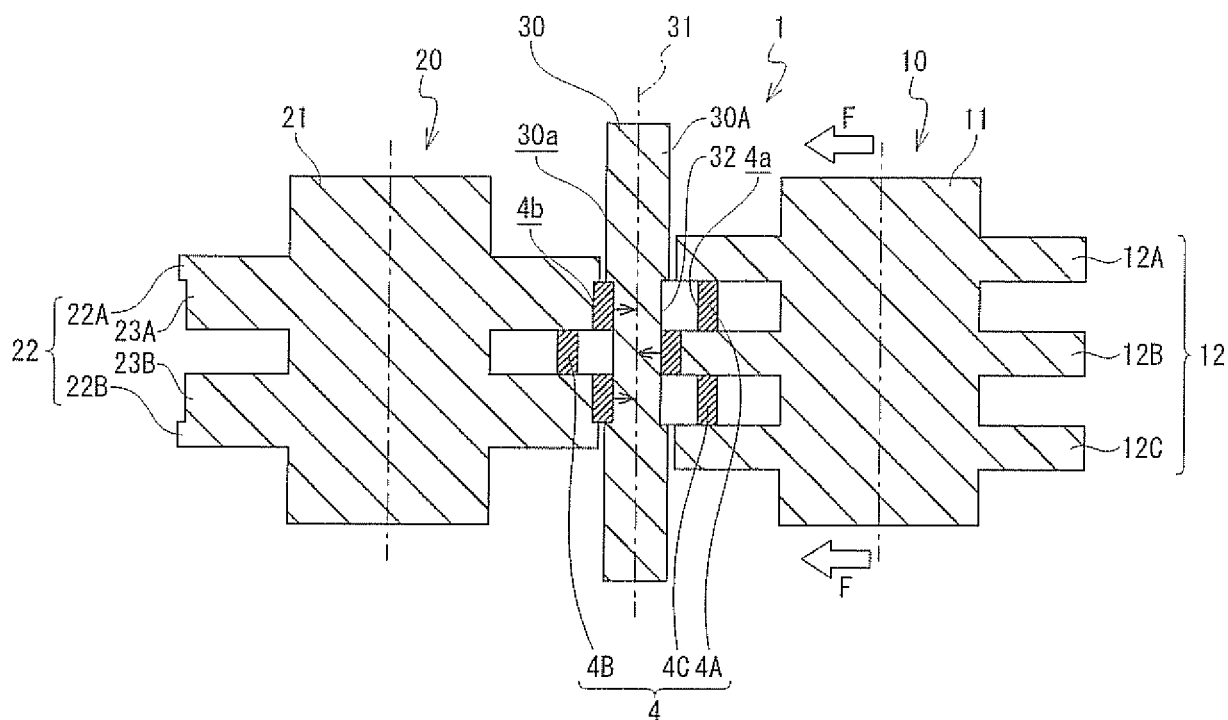


FIG. 7

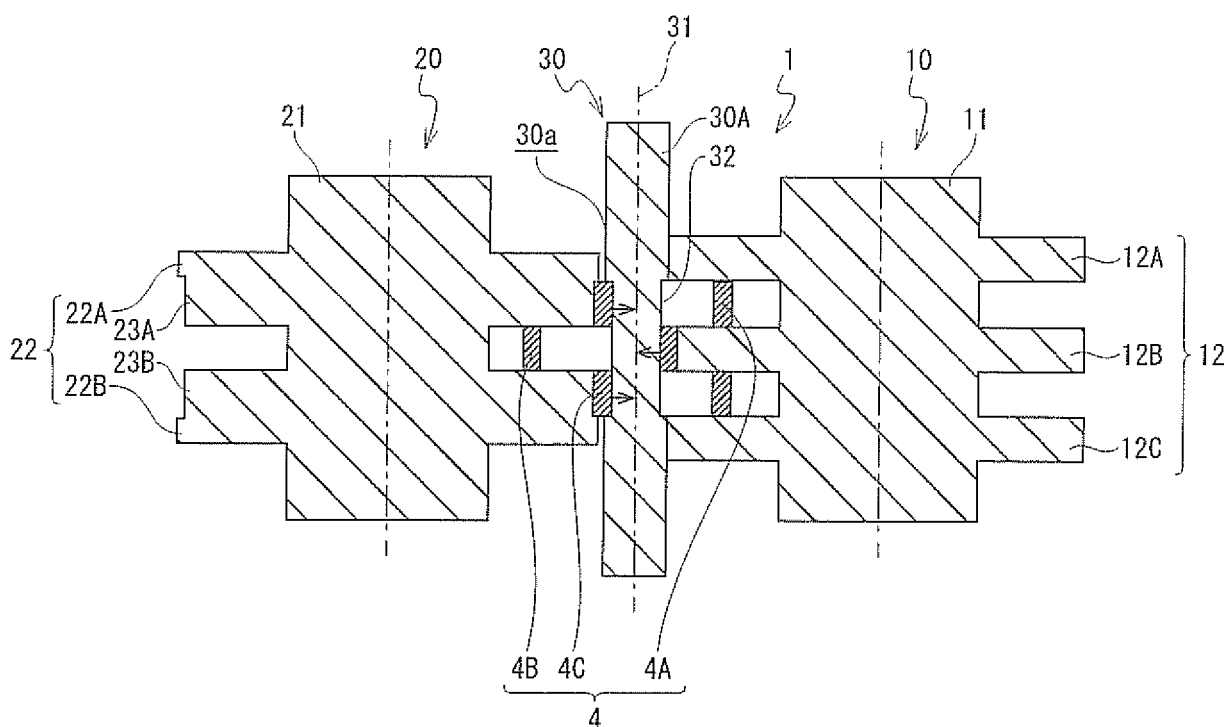


FIG. 8

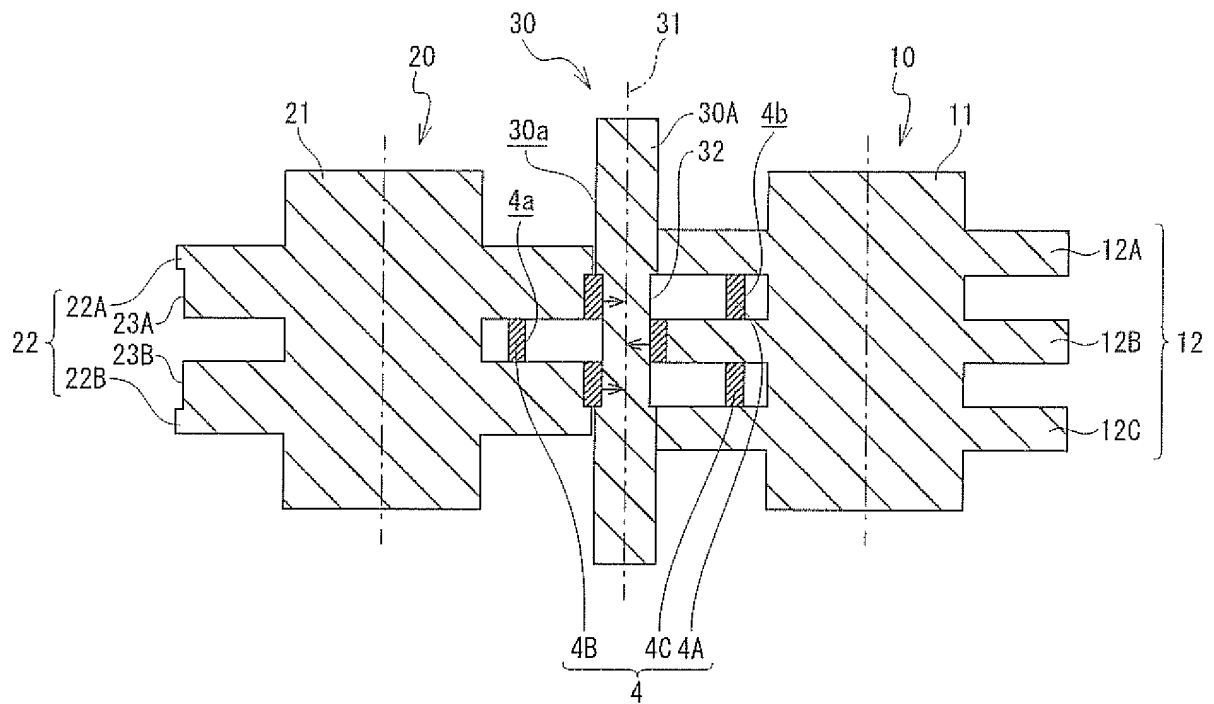


FIG. 9

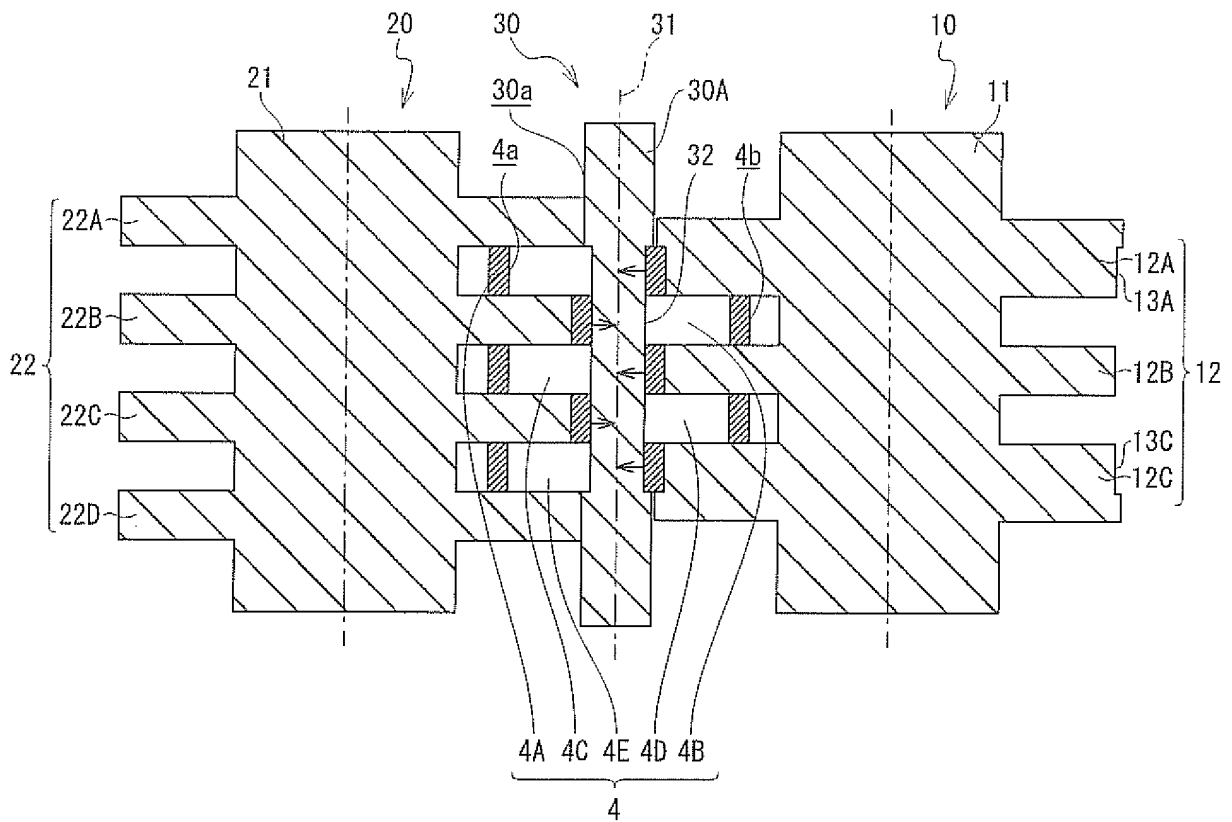


FIG. 10A

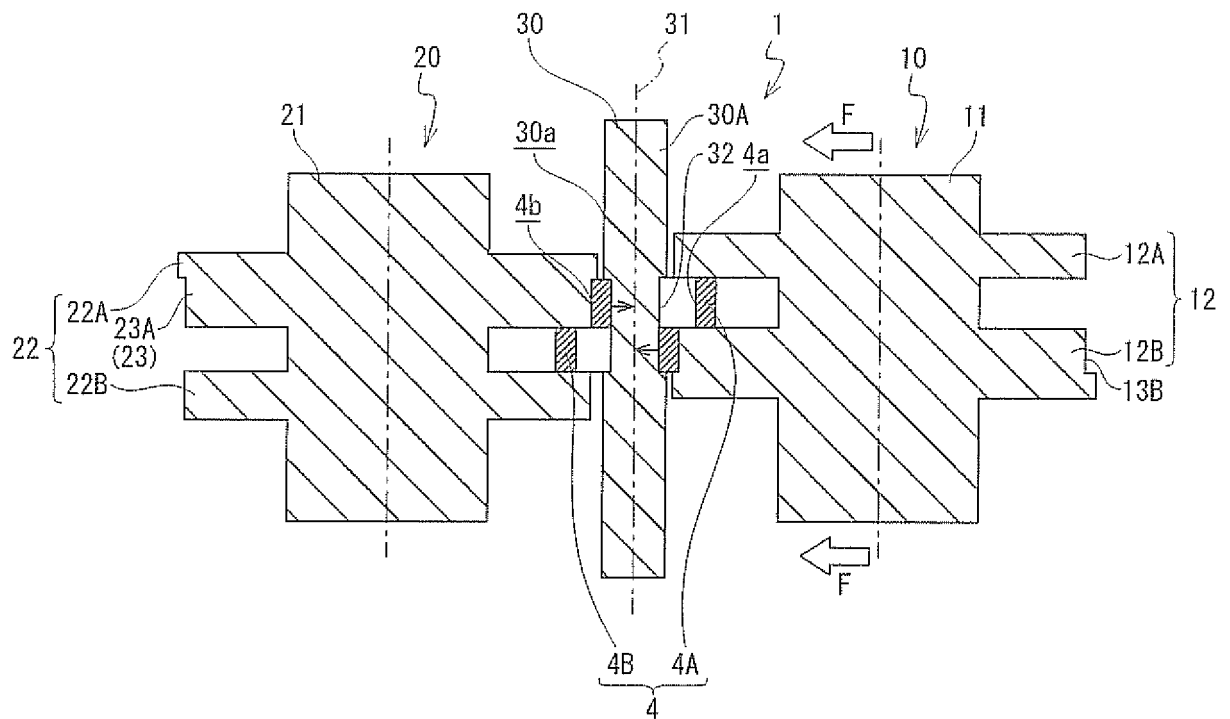


FIG. 10B

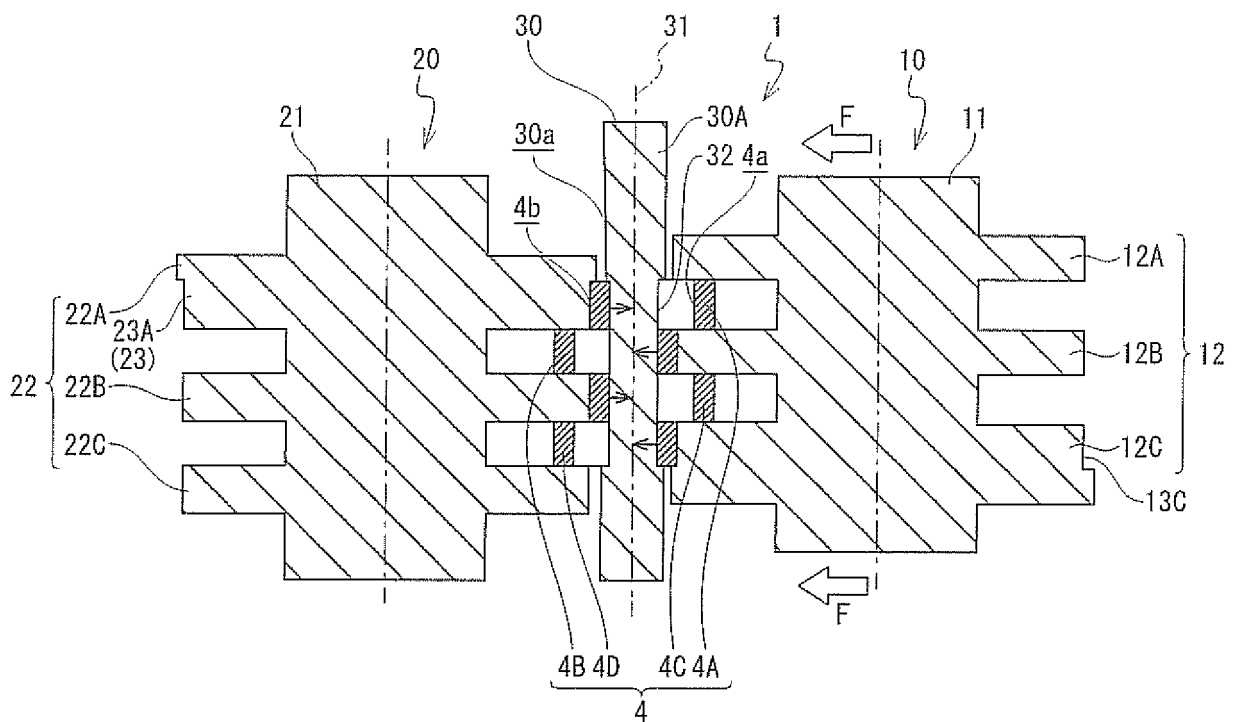


FIG. 11A

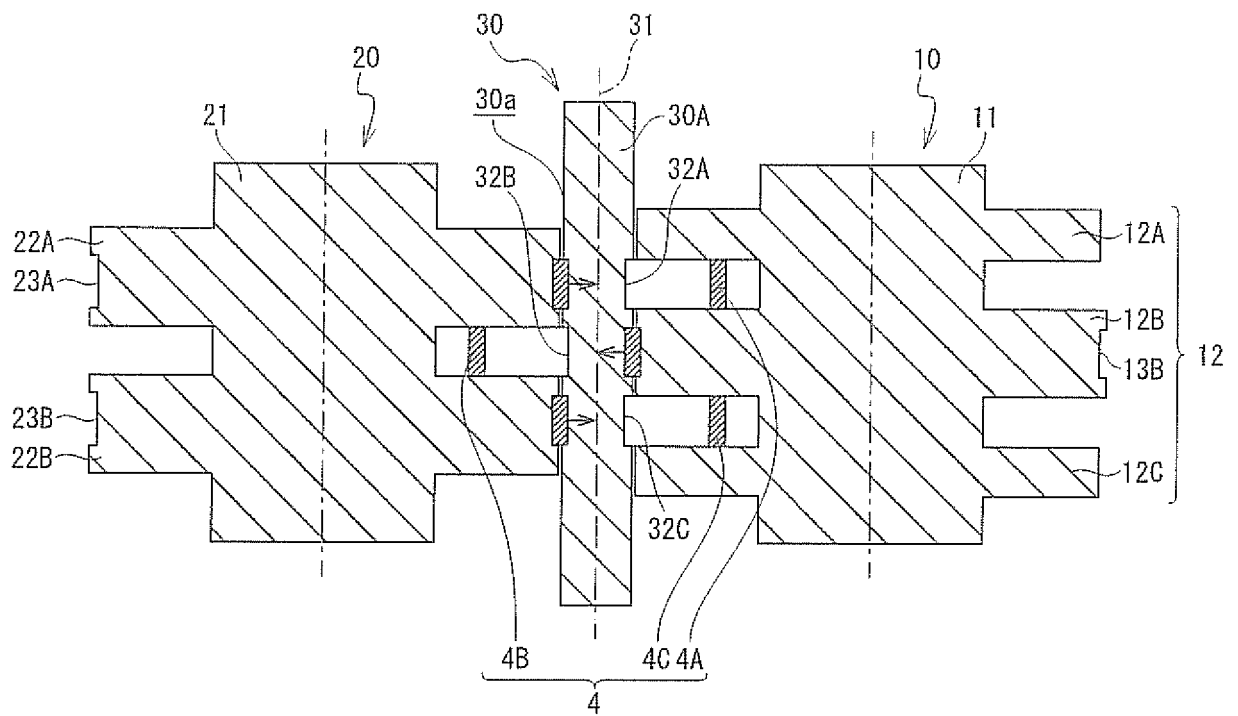


FIG. 11B

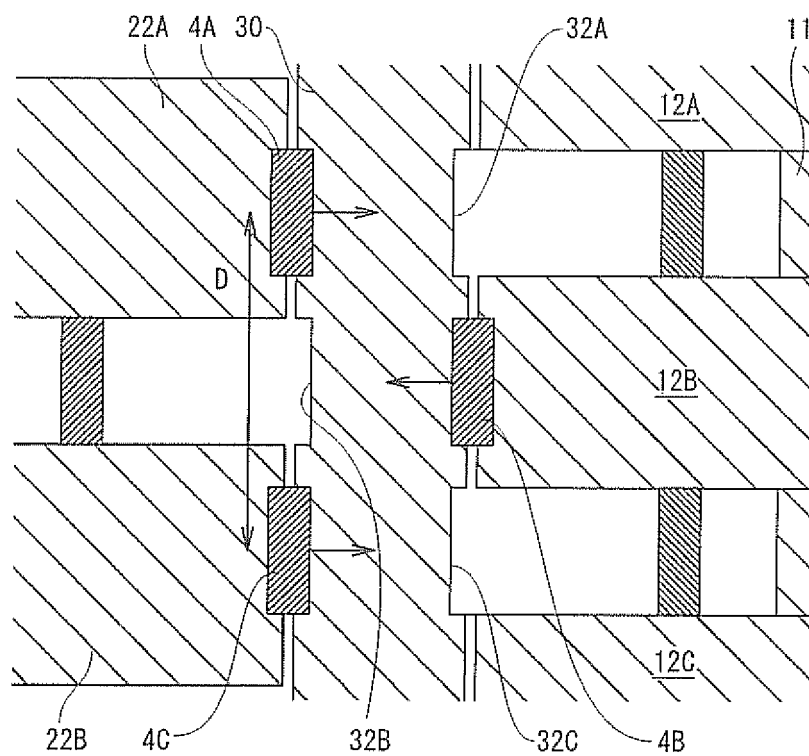


FIG. 12A

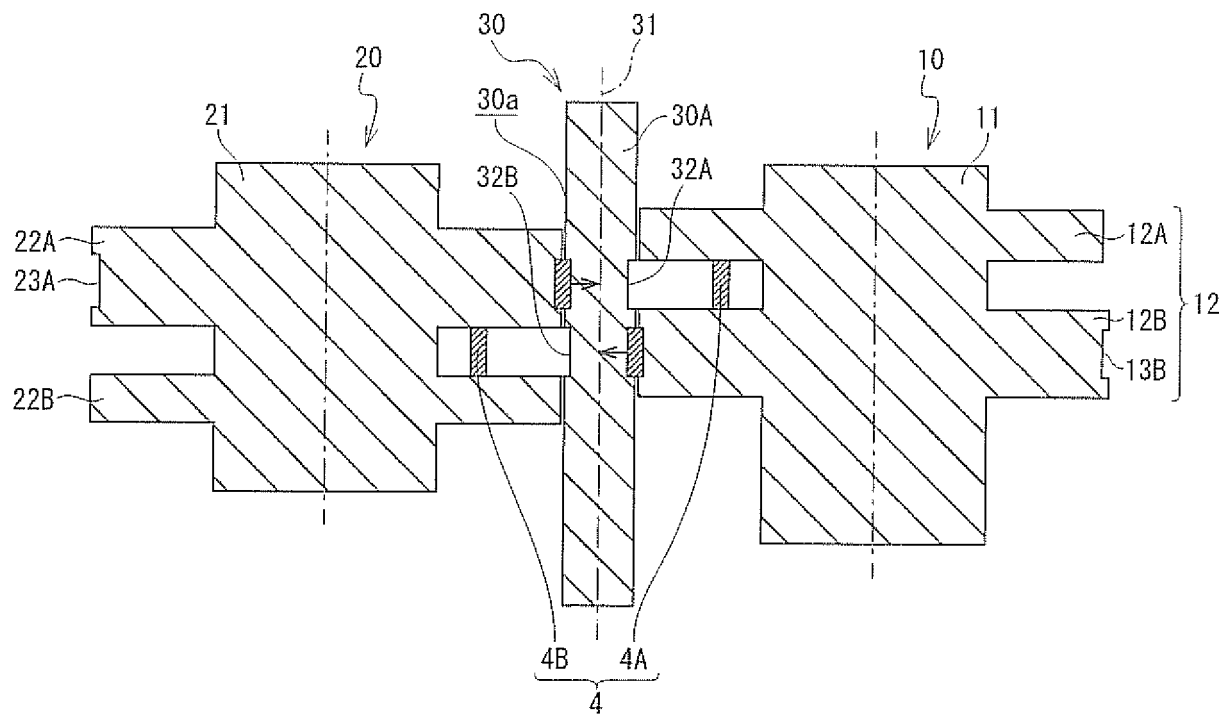


FIG. 12B

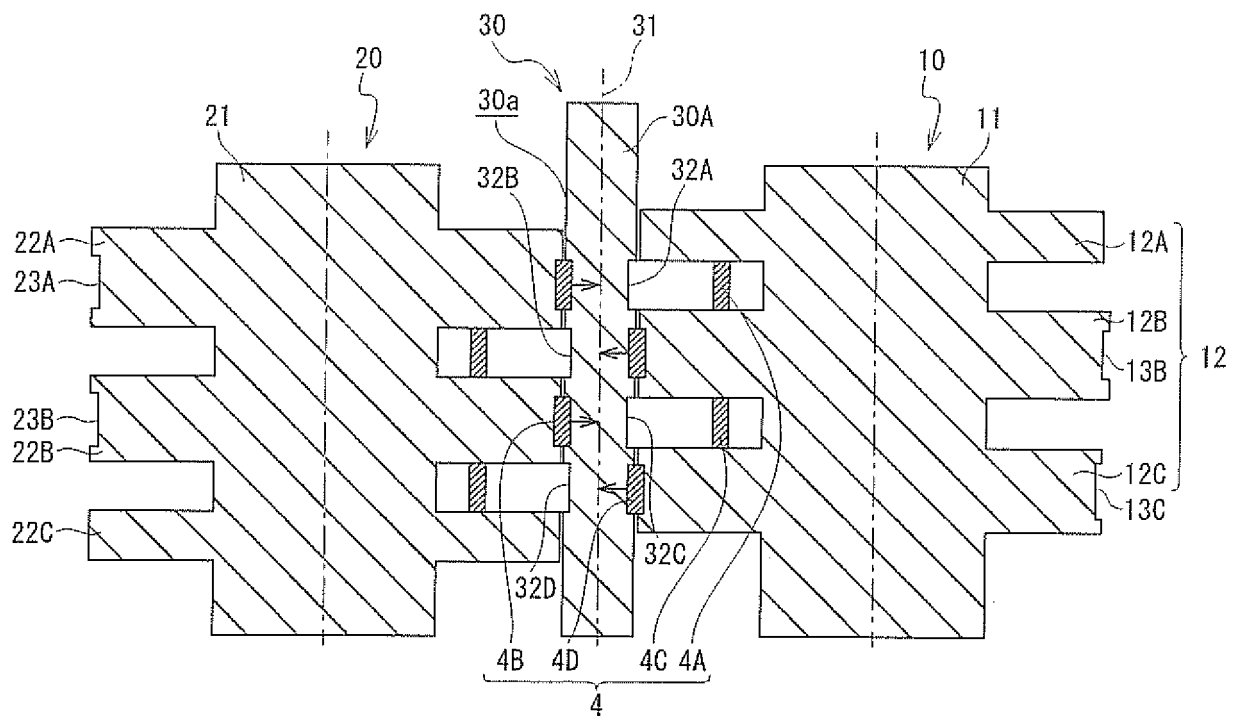


FIG. 13

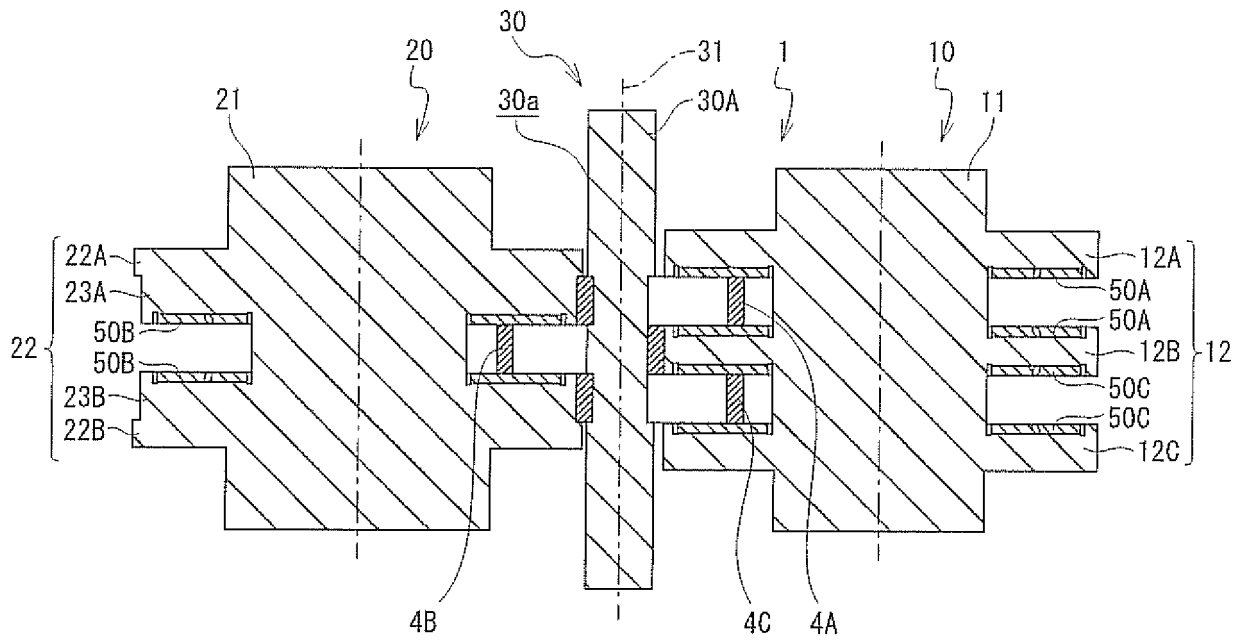


FIG. 14

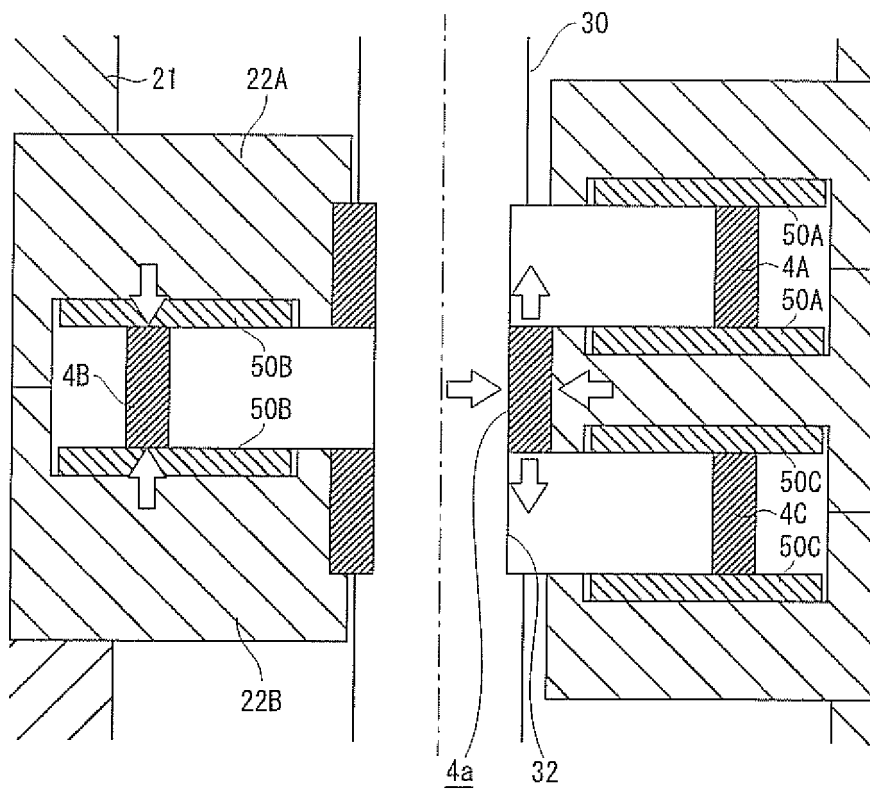


FIG. 15A

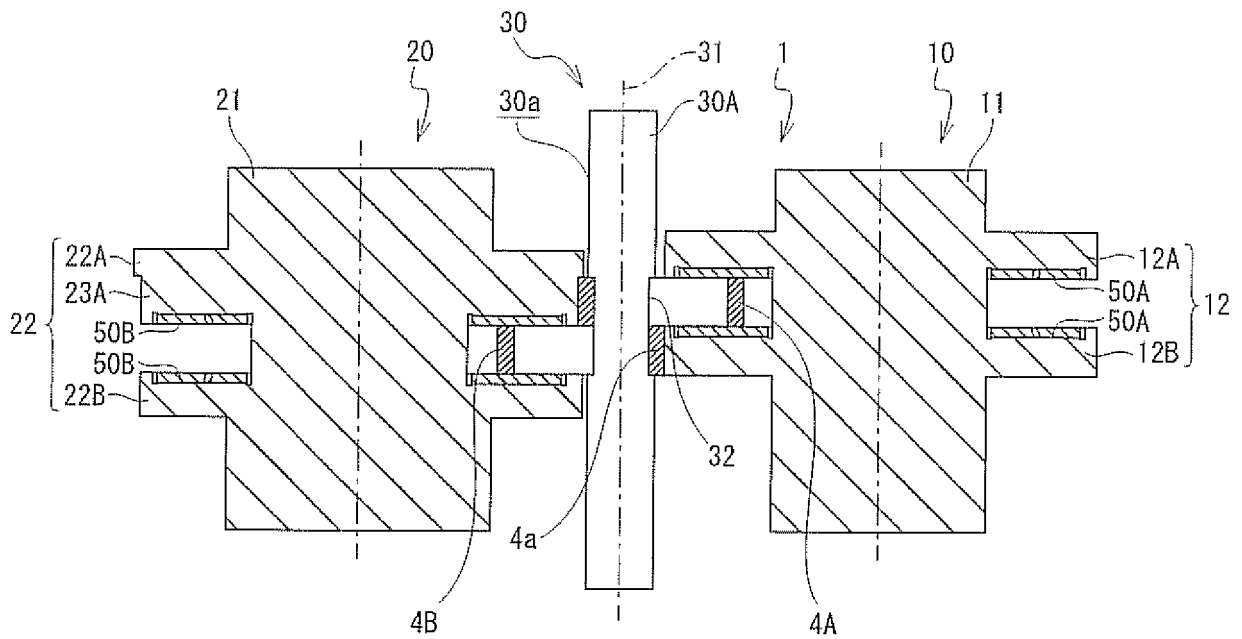


FIG. 15B

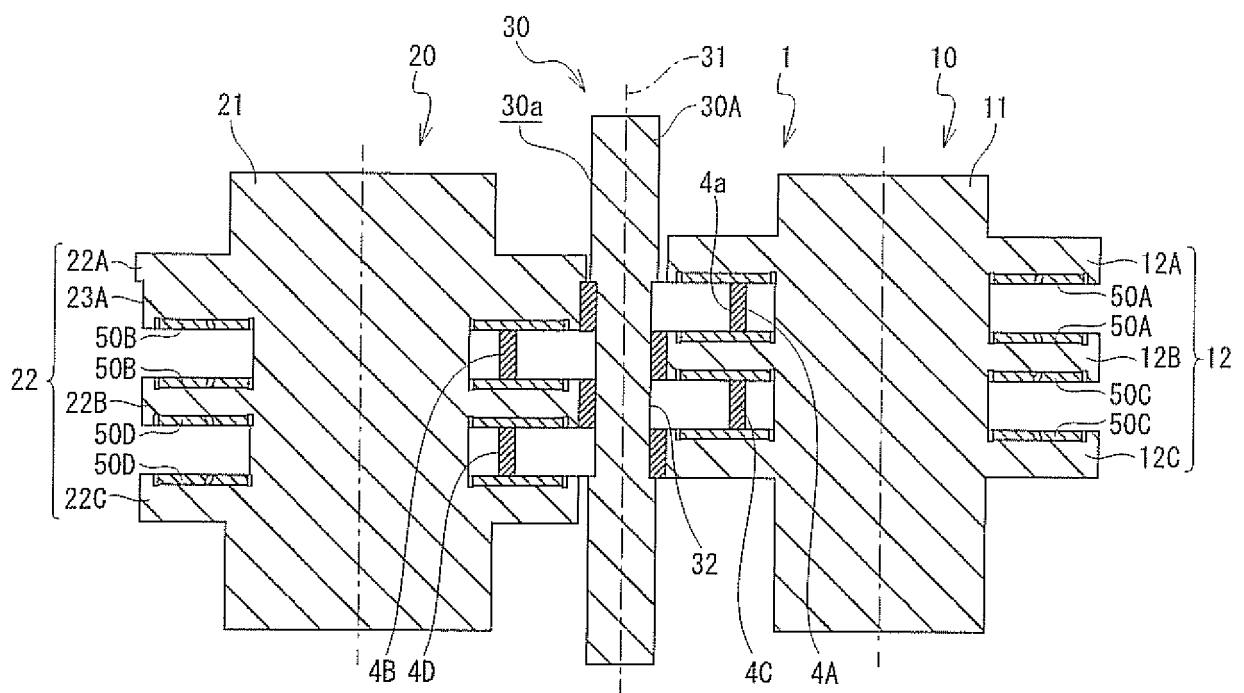


FIG. 16

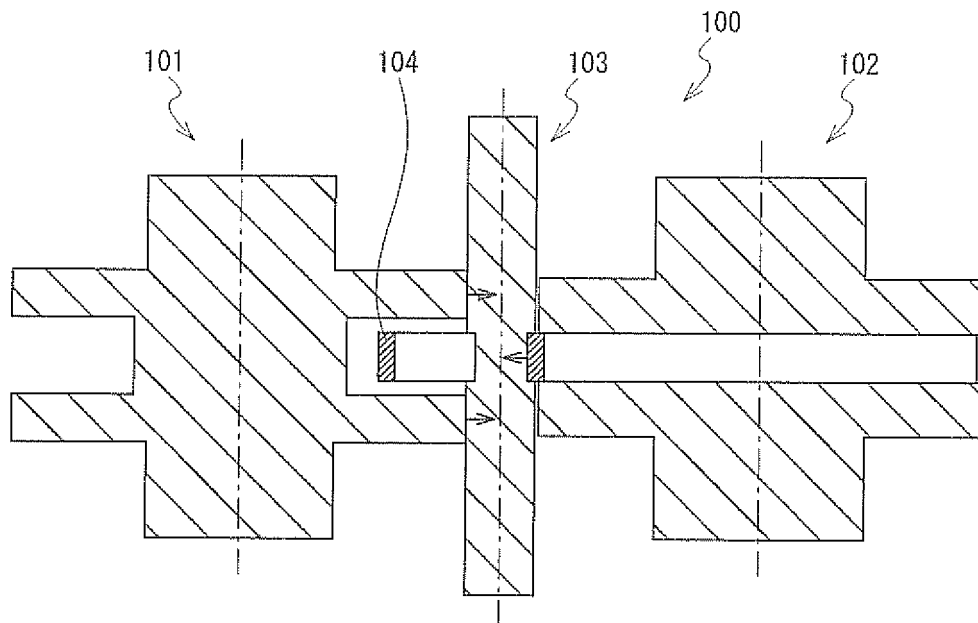
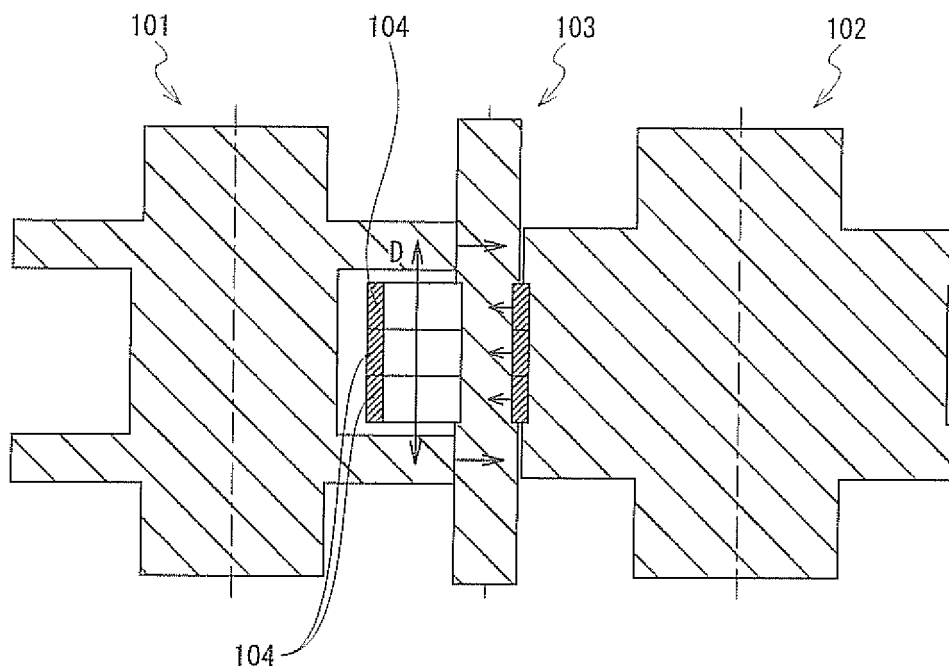


FIG. 17



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/001271

A. CLASSIFICATION OF SUBJECT MATTER

B21H1/12(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21H1/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 19634927 A1 (FA. CARL FREUDENBERG), 05 March 1998 (05.03.1998), column 4, line 1 to column 5, line 9 (Family: none)	1-8
A	DE 19920163 A1 (DR. SCHILLER WALZ- UND WERKZEUGTECHNIK GMBH), 02 November 2000 (02.11.2000), column 5, line 57 to column 7, line 59; fig. 1 to 3 (Family: none)	1-8
A	JP 2006-320927 A (Daido Steel Co., Ltd.), 30 November 2006 (30.11.2006), paragraphs [0010] to [0013]; fig. 2 (Family: none)	1-8

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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Date of the actual completion of the international search
07 May 2015 (07.05.15)Date of mailing of the international search report
19 May 2015 (19.05.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/001271

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 56-119611 A (Sacilor-Acieries et Laminoirs de Lorraine (S.A.)), 19 September 1981 (19.09.1981), page 6, lower left column, line 13 to page 7, upper left column, line 11; fig. 8 & US 4408475 A & GB 2068283 A & DE 3103532 A1 & FR 2474906 A1 & BE 887367 A & SU 978717 A & MX 152200 A & PL 229517 A & SE 8100421 A & AU 6671581 A & ES 499071 A & BR 8100627 A & CA 1156500 A & TR 20690 A & IN 155778 A & IT 1143353 A & ZA 8100668 A	1-8

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Patent documents cited in the description

- JP 62176627 A [0006]
- JP 56111533 A [0006]
- JP 2006320927 A [0006]